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AIR QUALITY MONITORING REPORT

FOR ALBERTA

1992

***Technical Report
Series***

Alberta

ENVIRONMENT





SUMMARY

JAN 31 1997

Alberta Environment and Protection has conducted air quality monitoring in the province since the early 1980s. The objectives of the monitoring program are to (1) provide data for the assessment of air quality against the regulatory and objectives (2) inform the public on the status of air quality; (3) monitor air quality in representative urban environments to determine whether exposure to air pollution; (4) report long-term trends in air quality; and (5) under the monitoring in special problem areas. In 1992, the air quality monitoring program consisted of continuous, interrupted, mobile, and special monitoring networks. Air quality monitoring data from continuous, interrupted, and mobile monitoring networks are summarized below. The regulations and guidelines for individual pollutants are discussed in detail in the main text of this report. Data from portable and mobile monitoring networks are available from independent Alberta Environmental Protection reports.

Continuous Air Quality Monitoring

Continuous monitoring is a key component of the air quality monitoring program. It provides a means of assessing the quality of the air in the province and of identifying areas where air quality is poor. The following table summarizes the results of the continuous monitoring program for 1992.

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AIR QUALITY MONITORING REPORT

FOR ALBERTA

1992

Technical Report Series No. 93-2a

Prepared by:

R.H. Myrick

Air Assessment Section
Environmental Quality Monitoring Branch
Environmental Assessment Division
Alberta Environmental Protection

December 1993

This report is one in a series of air quality annual reports produced by Alberta Environmental Protection for 1992. The following air quality annual reports are available for 1992:

Summary of Air Quality Monitoring in Alberta: 1992.

Air Quality Monitoring Report for Alberta: 1992 - Technical Report Series No. 93-2a.

Air Quality Monitoring Data Summary for Alberta: 1992 - Technical Report Series No. 93-2b.

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SUMMARY

Alberta Environmental Protection has conducted air quality monitoring in the province since the early 1960s. The objectives of the monitoring program are to: (1) provide data for the assessment of existing air quality relative to regulations and objectives; (2) inform the public on the status of air quality; (3) monitor air quality in representative urban environments to document human exposure to air pollution; (4) report long-term trends in air quality; and (5) undertake monitoring in special problem areas. In 1992, the air quality monitoring program consisted of continuous, intermittent, static, portable, mobile and acid precipitation monitoring networks. Air quality monitoring data from continuous, intermittent, static and acid precipitation networks are summarized below. The regulations and guidelines for individual pollutants are discussed in detail in the main text of this report. Data from portable and mobile monitoring networks are available from independent Alberta Environmental Protection reports.

Continuous Air Quality Monitoring

Continuous air quality monitoring is the measurement of pollutant concentrations on an 1-hour average basis. Pollutants that are monitored continuously by Alberta Environmental Protection include ammonia, carbon monoxide, carbon dioxide, the coefficient of haze (dust and smoke), hydrogen sulphide, oxides of nitrogen (including nitric oxide and nitrogen dioxide), ozone, sulphur dioxide and total hydrocarbons. Continuous monitoring stations are located in central, northwest and east Edmonton and in central, northwest and southeast Calgary. Continuous stations are also located in Fort Saskatchewan, Fort McMurray and Fort MacKay.

The Index of the Quality of the Air

The Index of the Quality of the Air (IQUA), which was developed by a federal-provincial committee in 1978, is a way of indicating air quality in simple and concise terms. The IQUA relates concentrations of five major continuously monitored pollutants (sulphur dioxide, carbon monoxide, ozone, nitrogen dioxide and the coefficient of haze) to a common scale which may be easily interpreted by the public. This scale associates Good, Fair, Poor and Very Poor air quality categories to federal and provincial air quality objectives. The IQUA is reported twice daily (8:15 a.m. and 3:15 p.m.), seven days a week, at Edmonton and Calgary.

Good air quality was reported the majority of the time at all Alberta Environmental Protection continuous monitoring stations in 1992. The frequency of good air quality ratings ranged from 85% at the Edmonton northwest station to 99% at the Fort McMurray monitoring station. The highest frequency of Poor air quality ratings was at the Edmonton northwest station (1.3% of the time). A Very Poor air quality episode was observed from 6 a.m. to 7 a.m. on September 29 at the Edmonton northwest station. This episode was caused by the combination of vehicular emissions with a very strong temperature inversion which persisted during the early morning hours limiting pollutant dispersion. Elevated levels of dust and smoke, carbon monoxide, oxides of nitrogen and total hydrocarbons were reported during this episode. All of these pollutants are primarily the result of automobile emissions. No other Very Poor air quality episodes were reported at Alberta Environmental Protection monitoring stations in 1992.

Ammonia

Ammonia is a colourless gas with a pungent odour. Ammonia is emitted into the atmosphere through natural sources such as animal decay and animal excretions, and man-made sources such as the fertilizer industry.

Ammonia was monitored during February and March at Fort Saskatchewan in 1992. The maximum 1-hour average ammonia concentration recorded at this location was 0.7 ppm. This value is 35% of the guideline for ammonia of 2.0 ppm. Ammonia concentrations were below the detection limit (0.1 ppm) 90% of the time during the monitoring period at the Fort Saskatchewan station.

Carbon Monoxide

Carbon monoxide is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles in urban areas. Minor sources of carbon monoxide include fireplaces, industry, aircraft and natural gas combustion.

The 1-hour regulation for carbon monoxide was exceeded at the Edmonton central (one hour), Edmonton northwest (nine hours) and Calgary downtown (three hours) monitoring stations in 1992. The 8-hour regulation was exceeded at the Edmonton central (six times) and northwest (15 times) monitoring stations, and the Calgary downtown (nine times), residential (four times) and industrial (two times) monitoring stations. The majority of exceedances of the 1- and 8-hour regulations occur during the months of November to February. The major factors which caused these exceedances were the combination of vehicle exhaust emissions and stagnant weather conditions which do not allow pollutants to disperse rapidly. A downward trend in carbon monoxide concentrations is evident at the Edmonton central and northwest stations, all Calgary stations, and the Fort McMurray station.

Carbon Dioxide

Carbon dioxide is a colourless, odourless, non-toxic gas that is produced by man through the combustion of fossil fuels. A major natural source of carbon dioxide is through the respiration process of plants and micro-organisms. Emissions of carbon dioxide by man have been suggested as being responsible for over half of the anthropogenic emissions of greenhouse gases.

Alberta Environmental Protection began monitoring carbon dioxide in downtown Calgary in March, 1991 and at Springbank (20 km west-northwest of downtown Calgary) in August, 1991. Average concentrations of carbon dioxide at the Calgary downtown and Springbank stations were 391 and 371 ppm, respectively. These values are higher than annual average concentrations recorded at Crossfield (40 km north of Calgary) from November, 1985 to October, 1987 which ranged from 345 to 348 ppm. Higher carbon dioxide concentrations in

downtown Calgary are related to fossil fuel combustion in the vicinity of Calgary. Alberta Environmental Protection does not have regulations for ambient concentrations of carbon dioxide.

The Coefficient of Haze

The coefficient of haze is an indicator of dust and smoke in the atmosphere which interferes with visibility. Dust and smoke may originate from road dust, wind-blown soil, industrial sources, automobile emissions, agricultural activities, forest fires and various other sources.

The guideline for the coefficient of haze (90% of values per month less than 1.0 COH unit) was not exceeded at any monitoring stations in 1992. Coefficient of haze values were much higher at urban stations in Edmonton and Calgary than at the more rural Fort Saskatchewan and Fort McMurray monitoring stations. Coefficient of haze values were typically greatest during the fall and winter when meteorological conditions inhibit pollutant dispersion. A small increase in annual average coefficient of haze values is indicated at the Edmonton east location. Slight downward trends in coefficient of haze values is evident at the Calgary residential and Fort Saskatchewan stations.

Hydrogen Sulphide

Hydrogen sulphide is a colourless gas with a rotten egg odour. Industrial sources include petroleum refineries, natural gas plants, petrochemical plants, coke oven plants, and pulp and paper plants which use the kraft pulping process.

The 1-hour regulation for hydrogen sulphide was exceeded at the Edmonton east (11 hours), Calgary industrial (four hours) and Fort Saskatchewan (13 hours) monitoring stations in 1992. The 24-hour regulation was exceeded two times at the Fort Saskatchewan station. Exceedances of these regulations were likely caused by fugitive emissions from industrial sources and sewage treatment facilities in the vicinity of the Edmonton east and Calgary industrial stations and from local industry at the Fort Saskatchewan station.

Nitrogen Dioxide

Nitrogen dioxide is a reddish-brown gas with a pungent odour. Sources of nitrogen dioxide in Alberta include the oil and gas industry, transportation (vehicle and aircraft emissions), power plants, natural gas and heating fuel combustion, and forest fires. The largest urban source of nitrogen dioxide is vehicular emissions.

The 1-hour and 24-hour regulations for nitrogen dioxide were not exceeded at any Alberta Environmental Protection stations in 1992. However, as in previous years, the annual average regulation of 0.030 ppm was exceeded at the Calgary downtown station. An annual average nitrogen dioxide concentration of 0.032 ppm was recorded at this location. Sources of

nitrogen dioxide include vehicle exhaust and heating fuel consumption. A downward trend in nitrogen dioxide is evident at the Edmonton central monitoring site.

Ozone

At ambient atmospheric concentrations, ozone is a colourless, odourless gas. However, ozone does have a distinctive odour and a bluish colour at higher concentrations. Ozone is generated in the atmosphere through a photochemical reaction between sunlight, nitrogen dioxide and hydrocarbons. Ozone may also be transported down to ground-level from the upper atmosphere.

Exceedances of the 1-hour regulation for ozone were not recorded at any Alberta Environmental Protection monitoring stations in 1992. As would be expected, the 24-hour regulation for ozone of 0.025 ppm was exceeded at all monitoring stations. The greatest frequency of exceedances was recorded at the Edmonton east and Calgary residential stations. The 24-hour regulation for ozone is often exceeded at pristine locations in Alberta. Sources of ozone which lead to exceedances of the 24-hour regulation include natural ozone generating processes such as: (1) the reaction of sunlight with naturally occurring hydrocarbons and oxides of nitrogen; and (2) transport of ozone to ground level from the upper atmosphere. Very small upward trends in ozone concentrations are evident from data collected at the Edmonton central, Calgary downtown and Fort McMurray monitoring stations.

Sulphur Dioxide

Sulphur dioxide is a colourless gas with a pungent odour. The most common sources of sulphur dioxide in Alberta are natural gas extraction plants, oil sands plants, coal-fired power plants, oil refineries, pulp and paper mills, fertilizer plants and diesel-powered transport vehicles.

One exceedance of the 1-hour regulation for sulphur dioxide was recorded at the Fort MacKay monitoring station in 1992. A peak 1-hour average value of 0.258 ppm was observed at this station. This value is one and a half times the regulation of 0.17 ppm. Elevated sulphur dioxide readings at this location were due to emissions from the oil sands processing plants located south of the Fort MacKay. The regulations for sulphur dioxide were not exceeded at any other monitoring stations.

Total Hydrocarbons

The term "total hydrocarbons" refers to non-reactive and reactive hydrocarbons. Non-reactive hydrocarbons, such as methane, occur naturally in the atmosphere. Reactive hydrocarbons (or volatile organic compounds) exist in the atmosphere primarily through man-made emissions. Reactive hydrocarbons may react in sunlight to form ozone. Sources of reactive hydrocarbons include vegetation, vehicular emissions, petroleum storage tanks and other industrial activities.

The highest annual average total hydrocarbon values occurred at the Edmonton central and east monitoring locations. The annual average concentration recorded at the Edmonton east station was significantly less than that observed at this location in 1991. Occasional occurrences of 1-hour average values greater than 10 ppm were recorded at this station. However, these occurrences were much less frequent than in 1991. Hydrocarbon concentrations greater than 50 ppm (the upper scale of the monitoring instrument) were recorded in June at the east Edmonton monitoring station. The highest 1-hour average total hydrocarbon concentration recorded at a location other than east Edmonton occurred at Fort Saskatchewan where a value of 8.0 ppm was recorded. Elevated hydrocarbons concentrations in east Edmonton and Fort Saskatchewan are due to fugitive emissions from industrial sources and vehicular emissions while vehicular emissions are the major source of hydrocarbons in downtown Edmonton and Calgary. Normal background total hydrocarbon concentrations are about 1.5 ppm. No regulations exist for ambient total hydrocarbon concentrations.

Intermittent Air Quality Monitoring

Suspended particulates were monitored at Edmonton (central, northwest and east stations), Calgary (downtown, residential and industrial stations) and Fort Saskatchewan in 1992. Monitoring of suspended particulates at the Ellerslie station was discontinued in September of 1991. Suspended particulates are monitored every sixth day in accordance with the National Air Pollution Surveillance (NAPS) monitoring scheme as a 24-hour accumulated loading. Chemical analysis is conducted on suspended particulate samples to quantify loadings of total suspended particulates, Benzo (a) Pyrene and lead.

Total Suspended Particulates

Suspended particulates are particles which range from about 0.001 to 500 microns in diameter (a human hair is about 100 microns in diameter) and, depending on their density, may remain suspended in the air for an indefinite period of time. Suspended particulates may originate from soil, road and agricultural dust; smoke from forest fires and recreational fires; vehicular exhaust emissions; and industrial sources.

The 24-hour regulation for total suspended particulates was exceeded occasionally at all suspended particulate stations in 1992. The highest number of exceedances was at the Calgary industrial station where the regulation was exceeded twelve times. This is compared to 18 exceedances recorded at the Calgary industrial location in 1991. The major sources of suspended particulates in these areas include vehicle exhaust, road dust and industrial emissions. With the exception of the Edmonton industrial station, suspended particulate loadings show a downward trend at all monitoring stations.

Benzo (a) Pyrene

Benzo (a) Pyrene is a polycyclic aromatic hydrocarbon (PAH) that is contained in all types of soot and smoke. Vehicular exhaust, and smoke from industrial and recreational emissions are the most common sources of Benzo (a) Pyrene.

Benzo (a) Pyrene loadings were significantly higher at monitoring stations located close to major traffic arteries (i.e. Edmonton central, Edmonton northwest, Calgary downtown and Calgary industrial). The major source of Benzo (a) Pyrene at these locations is vehicular emissions. Based on data collected from 1982 to 1990, Benzo (a) Pyrene loadings show a significant increase at the Edmonton northwest and Calgary residential monitoring stations. However, since 1990, Benzo (a) Pyrene loadings show a substantial decrease at most monitoring stations.

Lead

Lead is emitted into the atmosphere primarily as a result of burning leaded gasoline in motor vehicles. Other sources of atmospheric lead include iron and steel manufacturing, solid waste incineration and battery manufacturing.

Lead loadings were relatively low at all monitoring stations. The Edmonton central and Calgary industrial stations recorded the highest annual average lead loadings in 1992. Lead loadings at all monitoring stations show a substantial decrease over the past decade. This trend is a reflection of the decrease in the use of leaded gasoline.

Static Air Quality Monitoring

Alberta Environmental Protection conducts air quality monitoring, on a static basis, at approximately 51 networks throughout Alberta. Each network consists of one or more monitoring stations. Static monitoring is the measurement of total accumulated loadings of pollutants on a one- and three-month schedule. Parameters monitored on a static basis include total dustfall, calcium, total sulphation, hydrogen sulphide and fluorides.

Total Dustfall

Dustfall is defined as the fraction of particulate that does not remain suspended in the atmosphere for an indefinite period of time. Sources of dustfall include wind-blown soil, road dust, dust generated by agricultural activities, ash from forest fires and recreational fires, and flyash from industrial sources.

Total dustfall loadings exceeded Alberta Environmental Protection regulations for residential regions at most networks where total dustfall is monitored. Regulations for industrial regions were exceeded at eight of these networks. The highest frequency of exceedances of the

residential and industrial regulations for dustfall occurred at the Lethbridge network where these regulations were exceeded 92 and 50% of the time, respectively. The major sources of dustfall in Alberta include road dust, agricultural dust, dust from industrial sources, and vehicular exhaust.

Calcium

Calcium emanates from natural sources such as wind-blown soil and road dust. Man-made sources of calcium in dustfall include cement, iron, steel and wood processing.

As in previous years, the highest annual average calcium loading was recorded at the Exshaw network where a loading of 5.0 milligrams per 100 square centimeters per 30 days was reported. This value is almost two times higher than the calcium loadings recorded in the Edmonton area. Relatively high calcium loadings in the Exshaw region may be attributed to cement manufacturing activities in the area.

Total Sulphation

Total sulphation is the measurement of all sulphur-containing compounds which exist in the atmosphere. Sulphur recovery gas plants, coal-burning power plants and petroleum processing facilities are common sources of sulphation.

The highest annual average total sulphation values were recorded at the Diamond Valley and Redwater networks in 1992. One exceedance of the guideline for total sulphation was recorded at the Diamond Valley network. Relatively high annual average total sulphation loadings were also recorded at the Fort Saskatchewan, Waterton and Coleman monitoring networks. Relatively high loadings at these locations were likely caused by industrial activity in the region.

Hydrogen Sulphide

Hydrogen sulphide is present in the atmosphere from natural sources such as coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. Industrial sources of hydrogen sulphide include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, pulp and paper plants employing the kraft pulping process, and petroleum and gas gathering fields.

Exceedances of the guideline for hydrogen sulphide did not occur at any static monitoring networks in 1992. The highest annual average hydrogen sulphide loadings were observed at the Fort McMurray, Fort Saskatchewan, Sherwood Park and Redwater networks. Industrial activities in the region are the most likely sources of relatively high values at these locations.

Fluorides

Fluorides are emitted into the atmosphere through processes such as coal combustion and the processing of phosphate bearing rock. Alberta Environmental Protection operates two fluoride monitoring networks in the province.

Fluoride loadings were the highest at the Redwater monitoring network with an annual average loading of 2.8 micrograms per 100 square centimeters per 30 days. The guideline for fluoride loadings of 40 micrograms per 100 square centimeters per 30 days was not exceeded at any monitoring stations.

Acid Precipitation Monitoring

Precipitation chemistry was monitored, as an accumulation over a one-month period, from January to August at 12 locations in the province by Alberta Environmental Protection. The sampling interval at these stations was changed to weekly from September to December. The purpose of the network is to monitor the quality of precipitation, detect significant trends of precipitation quality and observe long-range transport of pollutants into the province. Chemical analysis was conducted on precipitation samples to obtain pH, as well as deposition of major cations and anions contained in the precipitation sample. In addition, the effective acidity of the precipitation was calculated.

pH

The most acidic (lowest pH) precipitation was recorded at the Fort McMurray precipitation monitoring station where an annual average pH value of 4.7 was observed. Relatively low annual average pH values were also measured at Beaverlodge, Cold Lake, High Prairie, Fort Chipewyan, Fort Vermilion, Red Deer and Kananaskis (pH of 5.2 or less). The Calgary and Suffield precipitation stations recorded annual average pH values close to that of uncontaminated precipitation (pH of 5.6).

Anion Deposition (sulphate, nitrate, chloride and phosphate)

Anions are negatively charged ions contained within precipitation which result when parent species react with water vapour. The parent species may be emitted into the atmosphere from coal-fired power plants, oil refineries, gas plants, oil sands plants, pulp and paper plants, fertilizer plants, vehicular emissions and agricultural activities.

The highest wet sulphate deposition rates were recorded at the Calgary and Kananaskis stations where values of 6.0 and 5.5 kg/ha/yr (kilograms per hectare per year) were observed, respectively. These values are substantially lower than the eastern Canada objective of 20 kg/ha/yr. Maximum wet nitrate deposition rates were observed at Kananaskis (3.5 kg/ha/yr), Calgary (3.1 kg/ha/yr) and Red Deer (3.0 kg/ha/yr). A maximum wet chloride deposition rate

of 1.5 kg/ha/yr was observed at Fort Chipewyan. Wet phosphate deposition was relatively low at all monitoring stations.

Cations (calcium, ammonium, sodium, magnesium, potassium)

Cations are positively charged ions which are formed when parent species go into solution. Cations may originate from industrial sources such as iron, steel and wood manufacturing, or natural sources such as wind-blown soil and dust. Agriculture processes such as fertilization and animal excretions are also a major source of ammonium.

Maximum wet ammonium deposition values were recorded at the Calgary station where a value of 3.7 kg/ha/yr was observed. Wet calcium deposition rates of 1.5 kg/ha/yr or greater were recorded at Fort Chipewyan, Calgary and Kananaskis. Wet sodium and magnesium deposition rates were at or below 0.5 kg/ha/yr at all precipitation monitoring stations. Wet potassium deposition rates were also below 0.5 kg/ha/yr at most stations with the exception of Fort Chipewyan where a value of 1.0 kg/ha/yr was recorded.

Effective Acidity

Effective acidity is an approach which has been developed to estimate the amount of acidity produced in the soil due to physical, chemical and biological processes which occur as a result of acid deposition. The highest calculated annual effective acidity rate occurred at Calgary where a value of 0.21 kg/ha/yr of H^+ (hydrogen ion equivalents) was estimated. Effective acidity rates at the remaining monitoring stations ranged from 0.03 to 0.08 kg/ha/yr of H^+ . The proposed range for effective acidity limits is 0.1 to 0.3 kg/ha/yr of H^+ for sensitive soils.

ACKNOWLEDGEMENTS

The report that follows details air quality activities that were conducted by Alberta Environmental Protection in the province of Alberta during 1992. A great deal of technical expertise is necessary to collect high quality data from such an extensive monitoring program. The dedicated individuals who established and maintained this comprehensive monitoring program are accredited with this accomplishment.

J. Torneby, D. Kupina, D. Bensler, J. Ross, E. Boyko, T. Spackman and B. MacGougan established and maintained the continuous, intermittent and static monitoring networks. E. Boyko was responsible for the operation of the acid precipitation monitoring network. Special acknowledgement is given to R. Brassard and his staff for the continual mechanical upkeep of ambient monitoring equipment. The Alberta Environmental Centre in Vegreville analyzed samples from the intermittent, static and acid precipitation monitoring networks.

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LIST OF ABBREVIATIONS

Monitoring Locations

EDMU	- Edmonton central (downtown) monitoring unit
ERMU	- Edmonton northwest (residential) monitoring unit
EIMU	- Edmonton east (industrial) monitoring unit
CDMU	- Calgary downtown monitoring unit
CRMU	- Calgary residential monitoring unit
CIMU	- Calgary industrial monitoring unit
EMMU	- Edmonton mobile monitoring unit (Fort Saskatchewan)
FMU	- Fort McMurray monitoring unit
FRMU	- Fort MacKay monitoring unit

Pollutant Parameters

IQUA	- Index of the Quality of the Air
NH ₃	- ammonia
CO	- carbon monoxide
CO ₂	- carbon dioxide
COH	- coefficient of haze
H ₂ S	- hydrogen sulphide
NO ₂	- nitrogen dioxide
NO	- nitric oxide
NO _x	- oxides of nitrogen
O ₃	- ozone
SO ₂	- sulphur dioxide
THC	- total hydrocarbons
TSP	- total suspended particulates
BaP	- Benzo (a) Pyrene
Pb	- lead
VOCs	- volatile organic compounds

Units of Measurement

ppm	- parts per million by volume
ppb	- parts per billion by volume
ug/m ³	- micrograms per cubic meter
ug/1000 m ³	- micrograms per 1000 cubic meters
kg/ha/yr	- kilograms per hectare per year
kg/ha/yr of H ⁺	- kilograms per hectare per year of hydrogen ion equivalent
mg/day/100 ²	- milligrams per day per 100 square centimeters
mg/100 cm ² /30 days	- milligrams per 100 square centimeters per 30 days
ug/100 cm ² /30 days	- micrograms per 100 square centimeters per 30 days
km/hr	- kilometers per hour
mm	- millimeters
ml	- millilitres
ueq/l	- micro-equivalences per liter
us/cm	- micro-siemens per centimeter

1. INTRODUCTION

Air quality is an issue which has received increased attention over the past decade. Alberta Environmental Protection recognizes that the quality of the environment is affected by the quality of the air, water and soil. The Environmental Quality Monitoring Branch of Alberta Environmental Protection has the responsibility of monitoring and reporting ambient air quality. When applicable, air quality is compared to established regulations and guidelines.

The Environmental Quality Monitoring Branch operates a comprehensive air quality monitoring program consisting of continuous, intermittent, static, mobile, portable and acid precipitation monitoring networks. The objectives of this air quality monitoring program are to:

- ▲ *provide data for the assessment of existing air quality relative to regulations and objectives;*
- ▲ *inform the public on the status of air quality;*
- ▲ *monitor air quality in representative urban environments to document human exposure to air pollution;*
- ▲ *report long-term trends in air quality; and*
- ▲ *undertake monitoring in special problem areas.*

This report documents and analyzes air quality data for 1992 from January 1 to December 31. When exceedances of the regulations or guidelines occur, an attempt is made to relate the exceedances to wind direction so that the source or sources of the pollutant may be identified. Long-term trends of pollutant concentrations are also presented and an explanation of these trends is included.

Air quality instrumentation and data are subject to a stringent quality control and quality assurance program. Instrument calibration and data collection procedures are detailed in the Alberta Environmental Protection Air Monitoring Directive (Alberta Environment 1989). After the data has been collected, monthly quality control is conducted by a technologist to ensure that the data presented in monthly and annual reports is certified as being correct. If the quality of the data is questionable, it is deleted from monthly and annual reports.

Detailed analyses of data collected by continuous, intermittent, static and acid precipitation monitoring networks that are operated by Alberta Environmental Protection are presented in this report. Data collected by portable and mobile monitoring programs are summarized in this report. The data used to generate this report are detailed in a separate document entitled "Air Quality Monitoring Data Summary for Alberta: 1992".

2. AIR QUALITY MONITORING NETWORKS

2.1 CONTINUOUS MONITORING NETWORK

Air pollutants are monitored on a continuous basis at nine locations in Alberta. Three continuous monitoring stations are located in each of Calgary and Edmonton. Additional stations are located in Fort Saskatchewan, Fort McMurray and Fort MacKay. Each continuous monitoring unit is equipped to monitor various air quality and meteorological parameters on an hourly basis. These parameters are listed in Table 2.1. The locations of continuous monitoring stations are presented in Figure 2-1 and Table 2.2.

The Edmonton monitoring stations are located in the central, northwest and east sections of the city. The Calgary stations are designated according to the general location of the stations in the central (Calgary downtown), northwest (Calgary residential) and southeast (Calgary industrial) areas of the city. All Edmonton and Calgary air quality stations are equipped to monitor ambient concentrations of carbon monoxide (CO), oxides of nitrogen (including NO, NO₂ and NO_x), ozone (O₃), total hydrocarbons (THC) and the coefficient of haze (COH). In addition, the Edmonton east and Calgary industrial monitoring units monitor sulphur dioxide (SO₂) and hydrogen sulphide (H₂S). With the exception of the Edmonton and Calgary downtown locations, all stations monitor wind speed and direction. Carbon dioxide (CO₂) monitoring was added at the Calgary downtown monitoring location in March of 1991 and at a temporary location near the Springbank airport in August of 1991.

The continuous monitoring unit located in Fort Saskatchewan monitors for the same pollutants as the Edmonton east monitoring station (i.e., CO, NO_x, NO, NO₂, O₃, THC, COH, SO₂ and H₂S) with the addition of ammonia (NH₃). The Fort McMurray monitoring station measures the same pollutants as the Edmonton east monitoring unit. Only SO₂, H₂S and THC are monitored at the Fort MacKay monitoring station.

2.2 INTERMITTENT MONITORING NETWORK

Suspended particulates are monitored, as a 24-hour accumulated loading, at each of the Edmonton and Calgary continuous monitoring locations as well as at Fort Saskatchewan (refer to Figure 2-1). Suspended particulate samples are collected by high-volume samplers and

Table 2.1 Pollutants monitored continuously at Alberta Environmental Protection monitoring stations.

Monitoring Station	Parameter									
	NH ₃	CO	CO ₂	COH	H ₂ S	NO _x ^a	O ₃	SO ₂	THC	Wind
Edmonton Central		X		X		X	X		X	
Edmonton Northwest		X		X		X	X		X	X
Edmonton East		X		X	X	X	X	X	X	X
Calgary Downtown		X	X	X		X	X		X	
Calgary Residential		X		X		X	X		X	X
Calgary Industrial		X		X	X	X	X	X	X	X
Fort Saskatchewan	X	X		X	X	X	X	X	X	X
Fort McMurray		X		X	X	X	X	X	X	X
Fort MacKay					X			X	X	X

^a includes NO₂ and NO

Table 2.2 Location of continuous monitoring stations.

Station Name	Station Location
Edmonton Central (Downtown) Monitoring Unit (EDMU)	10255 - 104 St.
Edmonton Northwest (Residential) Monitoring Unit (ERMU)	13335 - 127 St.
Edmonton East (Industrial) Monitoring Unit (EIMU)	105 Ave. and 17 St.
Calgary Downtown Monitoring Unit (CDMU)	611 - 4 St. S.W.
Calgary Residential Monitoring Unit (CRMU)	39 St. and 29 Ave. N.W.
Calgary Industrial Monitoring Unit (CIMU)	49 Ave. and 15 St. S.E.
Fort Saskatchewan Monitoring Unit (EMMU)	100 Ave. and 98 St.
Fort McMurray Monitoring Unit (FMMU)	Franklin Ave. at old waterpump house site
Fort MacKay Monitoring Unit (FRMU)	100 m west of the Fort MacKay Band Council Administration Office

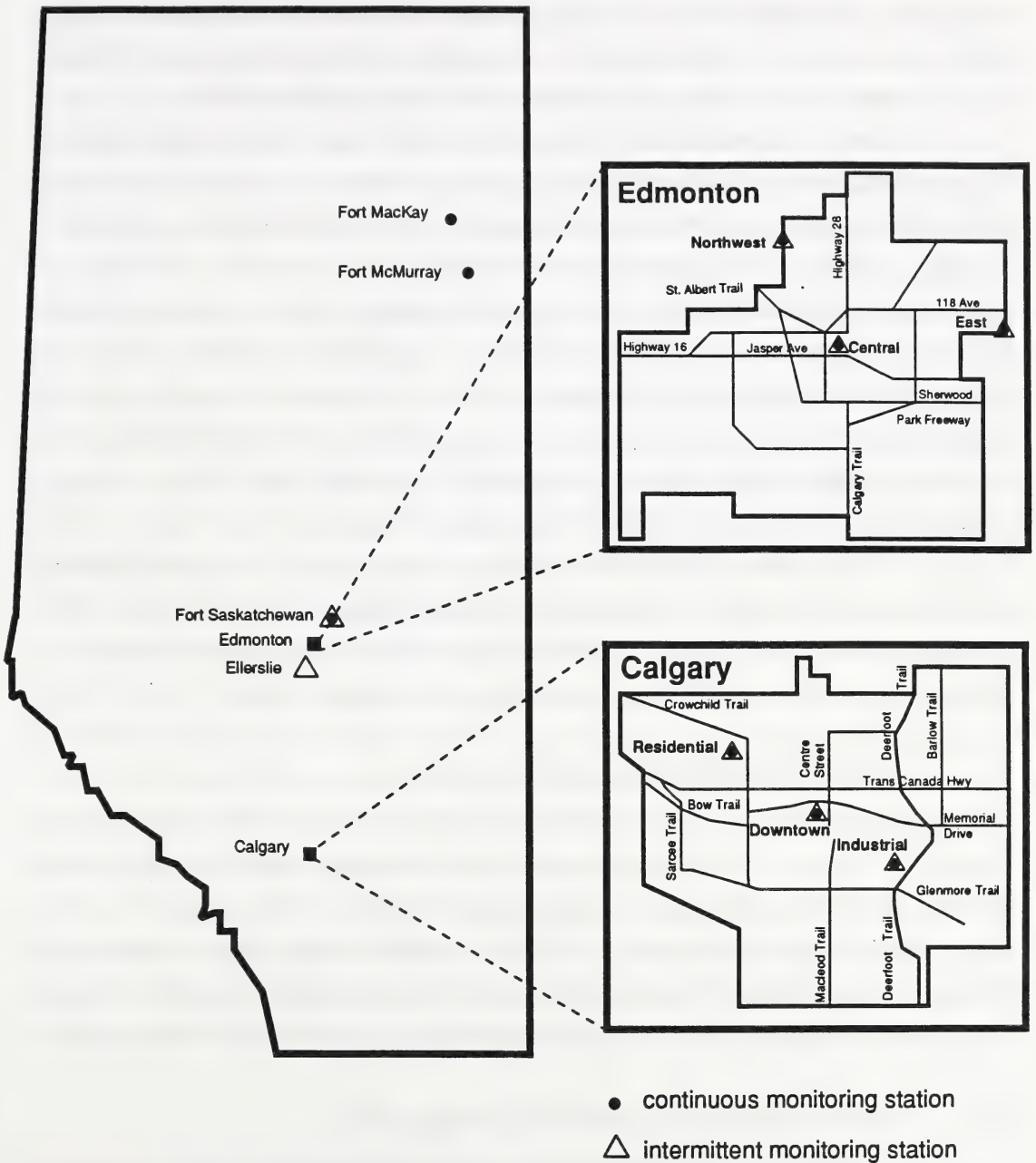


Figure 2-1 Location of continuous and intermittent air quality monitoring stations.

subsequently submitted for laboratory analysis to quantify loadings of total suspended particulates (TSP), Benzo (a) Pyrene (BaP) and lead (Pb). Suspended particulates are monitored on every sixth day according to the National Air Pollution Surveillance (NAPS) schedule.

In addition to suspended particulates monitored by high-volume samplers, Alberta Environmental Protection also operates two dichotomous samplers and one selective size inlet (SSI) sampler in the province. The dichotomous samplers are located at the downtown Edmonton and Calgary continuous monitoring locations while the SSI sampler is situated at the Edmonton central continuous monitoring station. The dichotomous sampler separates particulates into two size fractions; fine (less than 2.5 microns in diameter) and coarse (2.5 to 10 microns in diameter) (a human hair is about 100 microns in diameter) while the SSI sampler collects all particulates with a diameter less than 10 microns. The monitoring frequency of the dichotomous and SSI instruments conforms to the NAPS network schedule (i.e., every sixth day). These monitoring programs are conducted in cooperation with Environment Canada.

Volatile organic compounds (VOCs) are monitored, as a 24-hour integrated concentration, at the Edmonton central, Edmonton east and Calgary downtown stations. VOCs are also monitored every sixth day in accordance with the NAPS schedule. Analysis for over 115 VOCs and interpretation of VOC data is undertaken by Environment Canada.

2.3 STATIC MONITORING NETWORK

Static monitoring is the measurement of total accumulations of pollutant loadings over a specified time period. This time period is either one-month or three-months in duration. Total sulphation, hydrogen sulphide, total dustfall, fluorides and calcium are monitored on a static basis. Approximately 51 static monitoring networks are administered by Alberta Environmental Protection in the province. Figure 2-2 shows static monitoring network locations. Network locations and the number of monitoring stations per network are indicated in Tables 2.3 to 2.7.

2.4 PORTABLE MONITORING PROGRAMS

Portable monitoring programs are air monitoring projects that are initiated on the basis of public complaints, requests by municipal officials or for special projects. In 1992, portable monitoring programs were conducted in Fort McMurray and Springbank.

In late 1990 concerns were expressed by residents of Fort McMurray and Pollution Control Division regarding the representativeness of the Fort McMurray continuous monitoring location. Residents complained that odours were noticeable in downtown Fort McMurray when the monitoring station was measuring low odourous pollutant concentrations. Pollution Control Division of Alberta Environmental Protection questioned whether the original monitoring station was measuring air quality that was representative of downtown Fort McMurray. In response to these concerns, the Environmental Quality Monitoring Branch of Alberta Environmental Protection installed a second monitoring trailer in downtown Fort McMurray, between Manning Avenue and the Clearwater River, approximately one block northeast of Franklin Avenue. Air quality monitoring at these locations was conducted from October 1, 1991 to June 30, 1992.

The results of this monitoring program indicated that pollutants which are emitted by vehicular emissions (CO, COH and THC) generally recorded higher concentrations at the monitoring site located in downtown Fort McMurray. Ozone concentrations were also higher at the downtown location. Exceedances of the odour threshold for H₂S, and the regulations for H₂S and SO₂ were more frequent at the original Fort McMurray air quality station. As a result of data collected at these two stations, it was determined that the original site is still the most suitable location for monitoring air pollutants that are transported into the Lower Townsite of Fort McMurray from the oil sands facilities. In addition, the data obtained from the original location also adequately represents air quality of the urban environment within the Lower Townsite of Fort McMurray. A report detailing the results of this monitoring program is available from Alberta Environmental Protection (Myrick 1992).

Air quality monitoring for CO₂ at the Springbank airport, about 20 km west-northwest of downtown Calgary, began in August of 1991. The purpose of this project is to determine background CO₂ concentrations upwind of Calgary. Wind direction and speed are also monitored at this location. CO₂ and wind data collected at Springbank will be presented in this report.

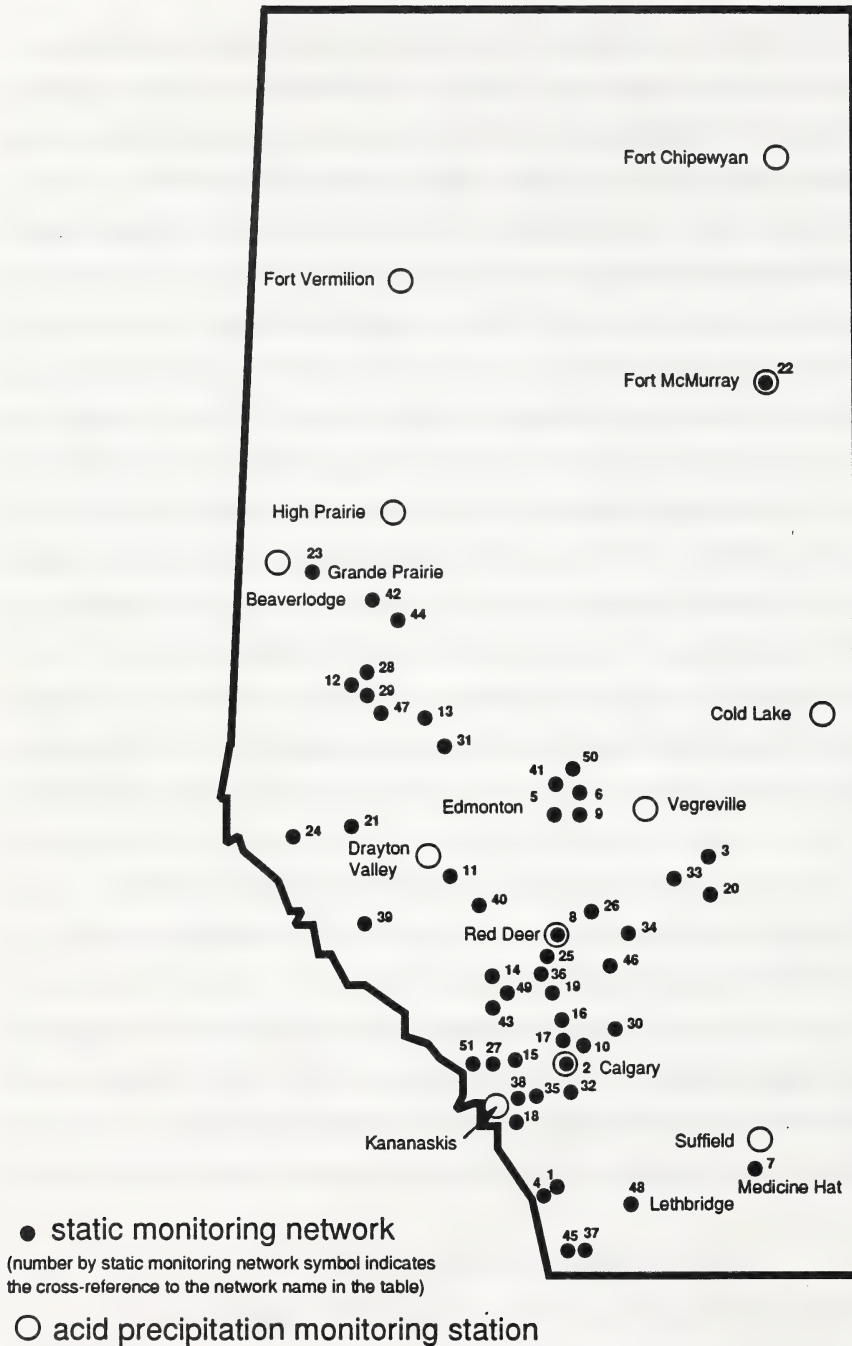


Figure 2-2 Location of static monitoring networks and acid precipitation monitoring stations.

Table 2.3 Location of networks where total dustfall is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Blairmore	2	1 month	1
Calgary	3	1 month	2
Camrose	1	1 month	3
Coleman	11	1 month	4
Edmonton	26	1 month	5
EDMU	1	1 month	5
EIMU	1	1 month	5
ERMU	1	1 month	5
Exshaw	5	1 month	51
Fort Saskatchewan (special)	1	1 month	6
Lethbridge	1	1 month	48
Red Deer	1	1 month	8
Sherwood Park	3	1 month	9

Table 2.4 Location of networks where calcium is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Edmonton	3	1 month	5
EIMU	1	1 month	5
ERMU	1	1 month	5
Exshaw	5	1 month	51

Table 2.5 Location of networks where hydrogen sulphide is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Balzac	4	3 months	10
Bigstone	2	3 months	12
Blue Ridge	4	3 months	13
Buck Lake	3	3 months	11
Caroline	1	3 months	14
Carstairs	4	3 months	16
Cochrane	4	3 months	15
Coleman	4	3 months	4
Camrose	1	1 month	3
Crossfield	5	3 months	17
Diamond Valley	4	3 months	18
Didsbury	5	3 months	19
Edburg	1	3 months	20
Edson	4	3 months	21
Fort McMurray	6	1 month	22
Fort Saskatchewan (special)	1	1 month	6
Grande Prairie	1	1 month	23
Hinton	3	1 month	24
Innisfail	2	3 months	25
Joffre	2	1 month	26
Jumping Pound	4	3 months	27
Kaybob	4	3 months	28
Kaybob (south)	4	3 months	29
Lone Pine Creek	5	3 months	30
Mayerthorpe	2	3 months	31
Mazeppa	4	3 months	32

Table 2.5 (cont.) **Location of networks where hydrogen sulphide is monitored on a static basis.**

Network Location	# of Stations	Monitoring Period	Map Location
New Norway	1	1 month	33
Nevis	7	3 months	34
Okotoks	5	3 months	35
Olds	4	3 months	36
Pincher Creek	6	3 months	37
Quirk Creek	6	3 months	38
Ram River	5	3 months	39
Red Deer (city)	2	1 month	8
Red Deer	4	3 months	8
Redwater	4	3 months	50
Rimbey	4	3 months	40
Sherwood Park	3	1 month	9
St. Albert	2	1 month	41
Simonette	2	3 months	42
Sundre	2	3 months	43
Valleyview	2	3 months	44
Waterton	8	3 months	45
Wimborne	2	3 months	46
Windfall	4	3 months	47

Table 2.6 Location of networks where total sulphation is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Balzac	4	3 months	10
Bigstone	2	3 months	12
Blue Ridge	4	3 months	13
Buck Lake	4	3 months	11
Calgary	11	1 month	2
Caroline	1	3 months	14
Carstairs	4	3 months	16
Cochrane	4	3 months	15
Coleman	4	3 months	4
Camrose	1	1 month	3
Crossfield	5	3 months	17
Diamond Valley	4	3 months	18
Didsbury	6	3 months	19
Edburg	1	3 months	20
Edmonton	26	1 month	5
EDMU	1	1 month	5
EIMU	1	1 month	5
ERMU	1	1 month	5
Edson	4	3 months	21
Fort McMurray	6	1 month	22
Fort Saskatchewan	4	1 month	6
Fort Saskatchewan (special)	1	1 month	6
Grande Prairie	1	1 month	23
Hinton	3	1 month	24
Innisfail	3	3 months	25
Joffre	2	1 month	26
Jumping Pound	4	3 months	27
Kaybob	4	3 months	28

Table 2.6 (cont.) **Location of networks where total sulphation is monitored on a static basis.**

Network Location	# of Stations	Monitoring Period	Map Location
Kaybob (south)	4	3 months	29
Lethbridge	5	1 month	48
Lone Pine Creek	5	3 months	30
Mayerthorpe	2	3 months	31
Mazeppa	4	3 months	32
Medicine Hat	4	1 month	7
New Norway	1	1 month	33
Nevis	7	3 months	34
Okotoks	5	3 months	35
Olds	4	3 months	36
Pincher Creek	6	3 months	37
Quirk Creek	6	3 months	38
Ram River	5	3 months	39
Raven Brood	3	1 month	49
Red Deer (city)	2	1 month	8
Red Deer	3	3 months	8
Redwater	4	3 months	50
Redwater	4	1 month	50
Rimbey	4	3 months	40
Sherwood Park	3	1 month	9
St. Albert	2	1 month	41
Simonette	2	3 months	42
Sundre	2	3 months	43
Valleyview	2	3 months	44
Waterton	8	3 months	45
Wimborne	2	3 months	46
Windfall	4	3 months	47

Table 2.7 Location of networks where fluoride is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Fort Saskatchewan	1	1 month	22
Redwater	4	1 month	50

2.5 MOBILE MONITORING UNITS

Alberta Environmental Protection operates four modified suburban trucks, equipped with H₂S and SO₂ monitors. One of these vehicles is also equipped to monitor THC. These mobile units are operated out of Fort McMurray, Whitecourt, Red Deer and Calgary.

Alberta Environmental Protection also operates a self-contained mobile laboratory that is equipped to monitor for CO, COH, H₂S, NO_x, NO, NO₂, O₃, SO₂ and THC. Mobile monitoring surveys conducted by the mobile laboratory in 1992 are summarized in Table 2.8. The mobile laboratory is equipped with a combined navigational and data acquisition computer. Its design enables analog and digital outputs from many instruments and transducers to be stored conveniently for later data analysis. Data reduction and analysis can be performed in the field enabling the operator to check the validity of the data and to report the essential data during or immediately following a survey (i.e. emergency response).

With the mobile monitoring program, pollutant concentrations can be obtained while the vehicle is stationary or when the vehicle is in motion. These units are especially important for emergency response air pollution episodes where fast response and portability are essential.

Table 2.8 Monitoring activities conducted by the mobile laboratory in 1992.

Monitoring Survey	Survey Date	Survey Objectives	Parameters Monitored
Edmonton Urban Survey	Mar 10,12,13 and 19	Evaluate pollutant levels at various locations in Edmonton.	H ₂ S, SO ₂ , CO, THC, NO, NO _x , NO ₂ , O ₃
Drayton Valley Airshed Survey	Aug 11	Preliminary survey of Drayton Valley area for zonal airshed study.	H ₂ S, SO ₂ , CO, THC, NO, NO _x , NO ₂ , O ₃

2.6 ACID PRECIPITATION MONITORING NETWORK

Precipitation chemistry was monitored from January to August, on a one-month basis, at 13 locations in the province by Alberta Environmental Protection during 1992. In September of 1992, the sampling interval for precipitation at all locations was increased to weekly. The locations of acid precipitation monitoring stations are indicated in Figure 2-2.

Recent studies have indicated that sampling of precipitation on a monthly basis does not adequately reflect precipitation chemical properties. A comparison of daily versus monthly samples shows that pH values and concentrations of other ions are consistently lower in daily samples. This is due to chemical reactions which take place while the sample remains in the field over the period of a month. Because of these discrepancies, Alberta Environmental Protection changed the frequency of precipitation monitoring from monthly to weekly. Daily sampling is not practical because of the increased load on the station operators and on laboratory analysis.

Precipitation chemistry samples are collected at the High Prairie station on a daily basis. As part of the Acid Deposition Program, precipitation is collected at the Vegreville station on a monthly, weekly and daily basis. Results from the Acid Deposition Program are summarized by Peake (1993). Laboratory analysis is conducted on precipitation samples to obtain the following parameters:

- . pH;
- . strong acidity;
- . total acidity;
- . specific conductance;
- . sulphate (dissolved) as SO_4^- ;
- . nitrate as NO_3^- ;
- . ammonia as NH_4^+ ;
- . chloride (dissolved) as Cl^- ;
- . ortho phosphate as PO_4^- ;
- . sodium as Na^+ ;
- . potassium as K^+ ;
- . calcium as Ca^{++} (dissolved); and
- . magnesium as Mg^{++} (dissolved).

3. FACTORS AFFECTING AIR POLLUTION DISPERSION

The quality of the air is dependent on the quantity of pollutants emitted into the atmosphere and the ability of the atmosphere to disperse the pollutants. Air pollution transport and dispersion is influenced by the temperature structure of the atmosphere, turbulence in the atmosphere, wind direction and wind speed, and the changes in these elements introduced by local topography.

3.1 TURBULENCE

When the earth's surface is heated by the sun, pockets of warm air will form near the ground. This less dense, warm air will rise from ground-level to be replaced by cooler air. The cooler air is, in turn, heated and thus ascends creating convective turbulence. This vertical motion in the atmosphere becomes more intense as solar heating increases. Convective turbulence causes vigorous atmospheric mixing which allows air pollutants to disperse rapidly. During daylight hours, when winds are light to moderate, atmospheric overturning, or convection, is the dominant mechanism for pollutant dispersion.

Under high wind speeds, the frictional force of air movement over the ground will create mechanical turbulence. The greater the wind speed, the more mechanical turbulence that is generated. Mechanical turbulence is the dominant mechanism for atmospheric mixing on windy days and at night when convective mixing is negligible.

3.2 TEMPERATURE STRUCTURE

The temperature in the lower atmosphere may increase or decrease with height depending on the amount of energy received from the sun. As evening approaches, the ground experiences a net heat loss to the atmosphere. As the ground cools, the lower levels of the atmosphere will also cool. The vertical temperature profile is now the reverse of the daytime situation; i.e., temperature increases with height. Heat loss from the earth's surface causes a temperature inversion which will limit plume rise from pollution sources. Temperature inversions are common in the winter when heat from the sun is minimal. The persistence of temperature inversions over a long period of time will lead to increased concentrations of air pollutants in the lower atmosphere.

When solar heating or heating from man-made sources (e.g. the urban heat island) is strong enough, a shallow well-mixed layer will develop near the ground. This layer, which may be "capped" by a temperature inversion aloft, is known as the mixing layer. The depth of the mixing layer defines the volume of air in which air pollutants can be mixed. The lower the depth of the mixing layer, the less volume that is available to disperse air pollutants. A persistent lack of a mixing layer or a shallow mixing depth may lead to high air pollution episodes. The mixing layer is especially important in urban locations where large quantities of pollutants are released near ground level.

3.3 WIND

Wind direction and wind speed will determine the trajectory, or path, of air pollutants from source to receptor. Mechanical turbulence created by high wind speeds will enable more rapid dispersion of air pollutants released near ground-level. Air pollution emitted by elevated stack sources may actually be transported more rapidly to the ground and, therefore, lead to higher ground-level pollutant concentrations.

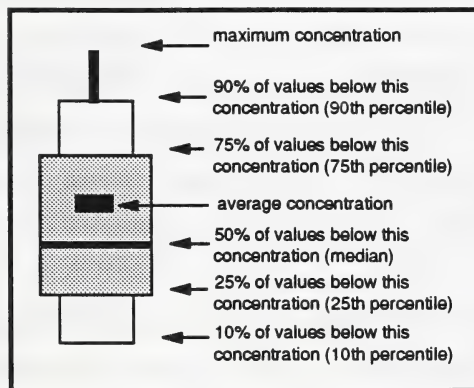
3.4 TOPOGRAPHY

The structure and orientation of terrain features will often influence and even control air motion and mechanical turbulence in the lower atmosphere. Small hills and trees may alter wind speed and direction while also enhancing mechanical turbulence. Larger terrain features such as mountains, hills and valleys may be a governing factor in the control of wind speed and wind direction. For example, wind may be diverted around large hills and mountains and channelled through valleys. Important diurnal variations of wind may also be caused by terrain features. A common cause for high pollution episodes is the occurrence of a persistent temperature inversion in a valley which contains numerous pollutant sources.

4. CONTINUOUS MONITORING RESULTS

Data analysis has been conducted on all parameters which are monitored continuously by Alberta Environmental Protection. A summary of the results of individual parameters collected by the continuous air quality network is preceded by a discussion of the Index of the Quality of the Air.

Concentrations of individual pollutants are summarized, on a monthly basis, in diagrams referred to as percentile diagrams or frequency distribution diagrams. An explanation of these diagrams is presented below:



Analysis of trends of continuously monitored parameters is presented when at least four years of historical data are available. Trend analysis was conducted through the application of Daniel's Trend Test (U.S. Environmental Protection Agency 1974; World Health Organization 1980). This is a non-parametric sign-rank test which ranks observations from lowest to highest and compares the rank to the chronological order of the observations. From this, a value of the Spearman Rank Correlation Coefficient may be obtained. A trend is considered significant if the probability of the trend being correct is 95% or greater; that is a 95% level of confidence has been established.

4.1 INDEX OF THE QUALITY OF THE AIR

The *Index of the Quality of the Air (IQUA)* is a system that has been developed to report ambient concentrations of specific pollutants in a manner that can be easily understood by the general public. The IQUA was developed by a federal-provincial committee in 1978 and adopted by Alberta Environmental Protection in December of 1979.

One way to describe the quality of the air is to report the concentrations of each pollutant. However, this can be confusing and make interpretation difficult because each pollutant has different potential effects at different concentrations. The IQUA relates the effects of different pollutants to a common scale which may be easily understood by the general public.

The IQUA converts the measurements of five major pollutants (SO_2 , O_3 , CO, the COH, and NO_2) to a single rating and corresponding air quality description. An IQUA rating of 1 to 25 indicates Good air quality; 26 to 50 is Fair air quality; 51 to 100 is Poor air quality; and an IQUA rating greater than 100 indicates Very Poor air quality. For example, a rating of 30 (Fair) for two individual pollutants indicates the same degree of environmental impact for each individual pollutant. The specific effects themselves, however, will vary according to the pollutant.

With the exception of the COH, the air pollutant concentrations are linked to regulations under Alberta's Clean Air Act and the National Air Quality Objectives. These regulations and objectives consider the effects of different pollutants on human health, animals, vegetation, or general concerns such as odour and visibility. The IQUA rating categories are defined in the Table 4.1.

The IQUA for Edmonton and Calgary is available to the Alberta public and media twice each day. Recordings of the index are issued at 8:15 a.m. and 3:15 p.m. in both cities. The index telephone number is 427-7273 in Edmonton and 250-2099 in Calgary. A total of 4049 calls were received by the IQUA telephone number at Edmonton in 1992. This is 82% more calls received by the IQUA telephone number as compared to 1991. The highest number of calls was on January 10 when 165 calls were received. This high frequency of calls corresponds to Poor IQUA readings from 9 a.m. on January 10 to 7 a.m. on January 11 at the Edmonton northwest monitoring station. Fair air quality readings were reported at the Edmonton central and east monitoring stations on January 10.

Table 4.1 Definition of IQUA rating categories.

IQUA rating	Frequency in Alberta	Effects
Good	almost all the time	Desirable range: no known harmful effects to soil, water, vegetation, animals, materials, visibility or human health. The long-term goal for air quality in Canada is to be in this range all the time.
Fair	occasional (typical when weather conditions inhibit pollutant dispersion)	Acceptable range: adequate protection against harmful effects to soil, water, vegetation, animals, materials, visibility and human health.
Poor	very seldom	Tolerable range: not all aspects of the environment are adequately protected from possible adverse effects. Long-term control action may be necessary, depending on the frequency, duration and circumstances of the readings.
Very Poor	very rare	Intolerable range: at this range, further deterioration of air quality and continued high readings could pose a risk to public health.

Source: Environment Canada (1980).

4.1.1 Results

The IQUA is calculated each hour and is summarized in monthly data reports for all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray continuous air quality monitoring stations. At Fort MacKay, only SO₂, H₂S and THC are monitored on a continuous basis, therefore, the IQUA is not calculated. A summary of the frequency of the IQUA categories and the contribution of each pollutant to the IQUA category is presented for each monitoring station in Figure 4-1. A monthly frequency distribution of the IQUA category and pollutants that contribute to the IQUA category are illustrated in Figures 4-2 and 4-3, respectively.

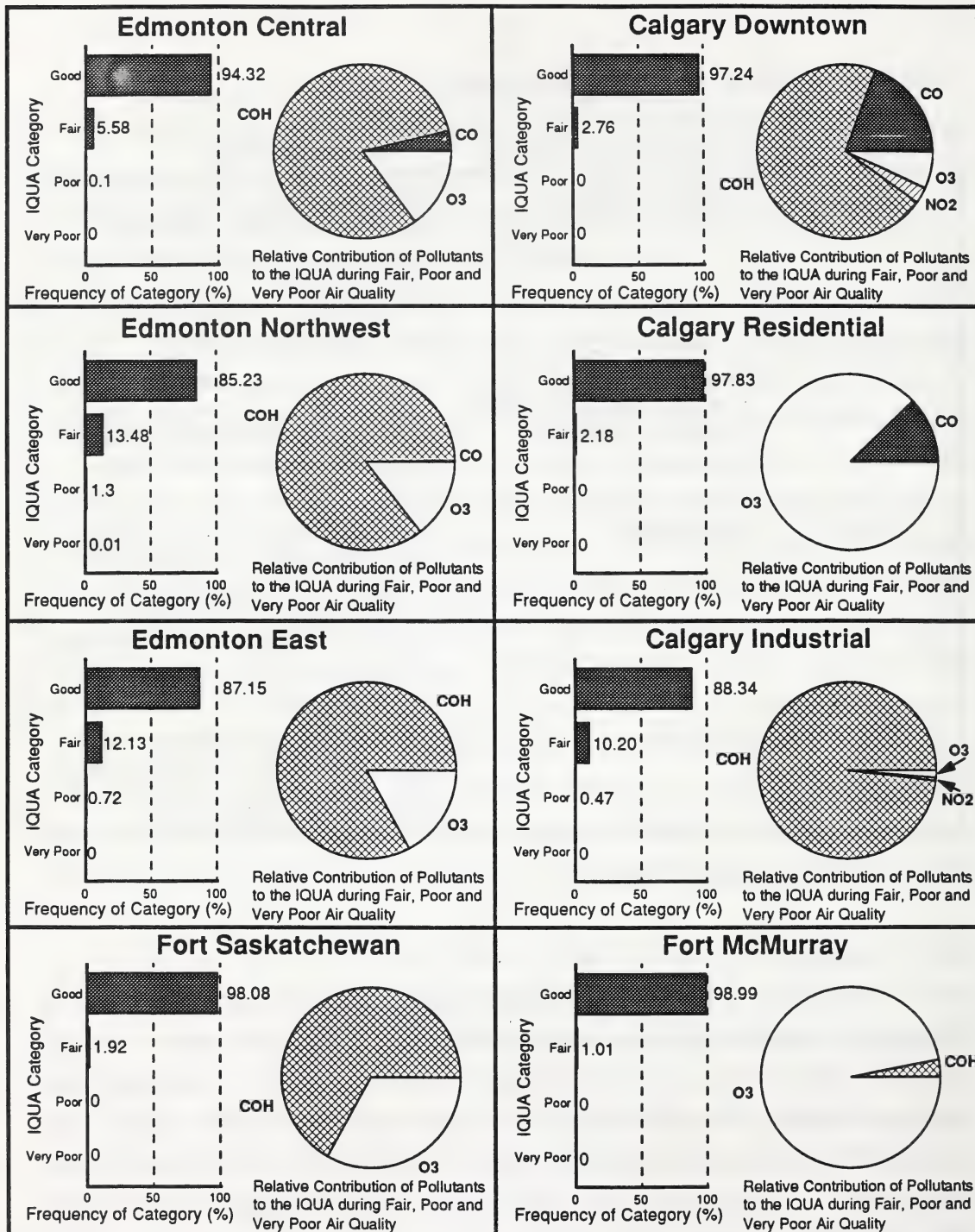


Figure 4-1 Annual frequency distribution of the IQUA category and the pollutants that contribute to the IQUA for 1992.

Edmonton 427-7273
Calgary 250-2099

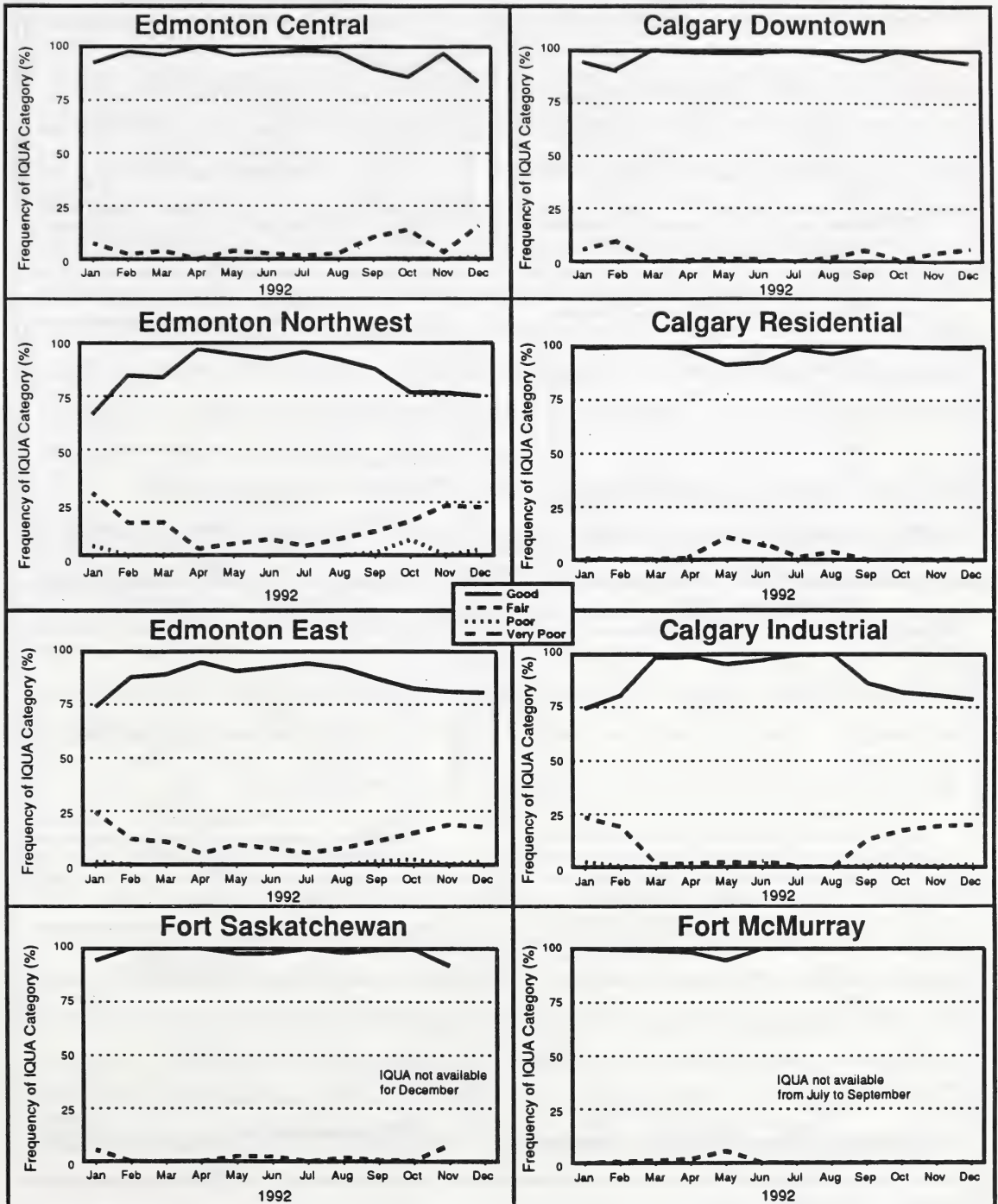


Figure 4-2 Monthly frequency distribution of the IQUA category.

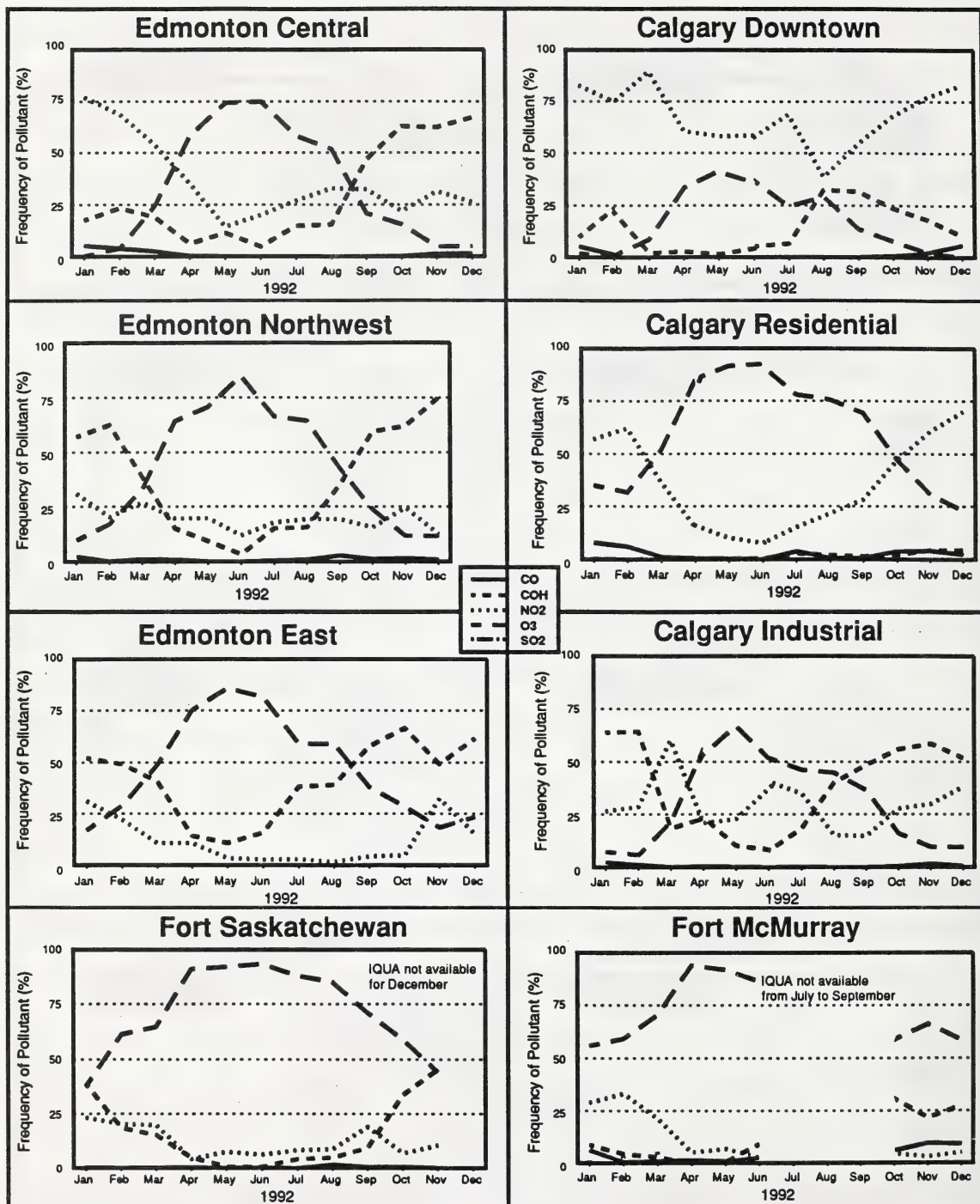


Figure 4-3 Monthly frequency distribution of pollutants contributing to the IQUA category.

As in previous years, Good air quality ratings were observed the majority of the time at all Alberta Environmental Protection air quality monitoring stations. The frequency of Good air quality ratings ranged from 85% at the Edmonton northwest station to 99% at the Fort McMurray station. Fair air quality ratings were most frequent at the Edmonton northwest (13.5%), Edmonton east (12.1%) and Calgary industrial (10.7%) monitoring stations. Poor air quality ratings were reported at all Edmonton stations and the Calgary industrial station. The highest frequency of Poor ratings was at the Edmonton northwest station (1.3%). Very Poor air quality was observed for one hour at the Edmonton northwest monitoring station. This air quality episode was due to high levels of dust and smoke in the atmosphere. Very Poor ratings were not observed at any other monitoring stations in 1992.

The pollutants responsible for the IQUA ratings are largely dependent on the location of the air quality station in relation to the source or sources. When the IQUA was Fair, Poor or Very Poor, the COH was the dominant pollutant at stations located close to major traffic arteries or industrial sources. Ozone is the dominant pollutant at air quality stations with less influence from vehicle traffic or industrial sources. Carbon monoxide from vehicle exhaust occasionally is responsible for Fair or worse IQUA ratings at the Edmonton central, Calgary downtown and Calgary residential stations.

4.1.1.1 Edmonton

The frequency of Good air quality ratings ranged from 85% at the Edmonton northwest monitoring location to 94% at the Edmonton central station. Fair, Poor and Very Poor air quality ratings were most frequent at the northwest station. Good air quality was most common from April to August at all three Edmonton stations. The highest frequency of Fair air quality ratings occurred in January at the northwest station where the IQUA was in the this category almost 30% of the time. Poor air quality ratings were most frequent in October (7.3%) and January (4.2%) at the Edmonton northwest monitoring station. The highest monthly frequencies of Poor air quality events at the central and east stations were recorded in December (0.9%) and October (2.6%), respectively.

An air quality episode consisting of a Very Poor air quality rating occurred for one hour from 6 a.m. to 7 a.m. on the morning of September 29 at the northwest monitoring station. Even though this episode was short in duration, a maximum hourly IQUA value of 113 was

recorded. The pollutant which caused this high IQUA reading was the COH or dust and smoke in the atmosphere. High concentrations of CO, NO_x and THC were also reported during this time period. A relatively high frequency of occurrence of very stable atmospheric conditions in the fall occasionally leads to events where pollutants are not able to disperse rapidly and thus result in Poor air quality. The September 29th episode was linked to the combination of vehicle emissions with a very strong temperature inversion which persisted for a short time in the early morning hours.

NO₂ was the dominant pollutant which contributed to air quality ratings observed in the winter at the central monitoring station while the COH was most common in the fall. At the northwest and east monitoring stations, the COH contributed to the IQUA most frequently in the fall and winter. O₃ becomes the predominant pollutant in the spring and summer at all Edmonton monitoring stations.

4.1.1.2 Calgary

Good air quality was evident from 89% of the time at the Calgary industrial location to 98% at the Calgary residential station. Fair air quality ratings were also most frequent at the industrial monitoring station located in southeast Calgary (10.2%). Poor air quality was reported only at the industrial monitoring station. The air quality index did not enter the Very Poor range at any Calgary monitoring stations in 1992. Good air quality was most frequent at the downtown and industrial stations during the spring and summer. The air quality index was in the Good range over 95% of the time in every month at the residential station with the exception of May and June. Poor air quality was evident in January and February and from September to December at the industrial station.

At the downtown station where the major emission source is vehicles, NO₂ was the dominant pollutant for all months that data is available. At the industrial station, the COH was the most common pollutant in the winter and fall with O₃ becoming dominant in the spring and summer. NO₂ also contributes significantly to the IQUA at the industrial station especially in March where NO₂ is responsible for 60% of IQUA ratings at this location. At the residential monitoring station, NO₂ contributes to the IQUA most frequently in the late fall and winter with O₃ becoming the major pollutant from March to October.

4.1.1.3 Fort Saskatchewan

Good air quality was reported 98% of the time at the Fort Saskatchewan monitoring station. This is a significant increase over the previous year where the IQUA was in the Good category 89% of the time on an annual basis. Fair air quality occurred less than 2% of the time at the Fort Saskatchewan station in 1992. Over 97% of IQUA readings from February to October were in the Good category. Fair air quality occurred most often in January and November. The IQUA is not available for December due to a relocation of the monitoring station. The major pollutant responsible for IQUA readings from February to October was O_3 . NO_2 was the predominant pollutant in the remaining months.

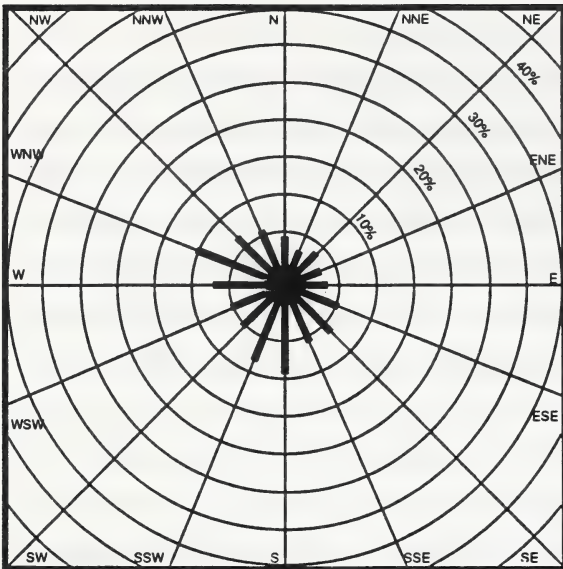
4.1.1.4 Fort McMurray

Good air quality occurred over 99% of the time in all months with the exception of the spring (March, April and May) at the Fort McMurray station in 1992. During March, April and May, natural O_3 concentrations are higher which lead to a greater frequency of Fair air quality. O_3 was the dominant pollutant that contributed to the IQUA in all months for which data is available. The IQUA is not available from July to September due to renovation of the site and instrumentation.

4.2 WIND

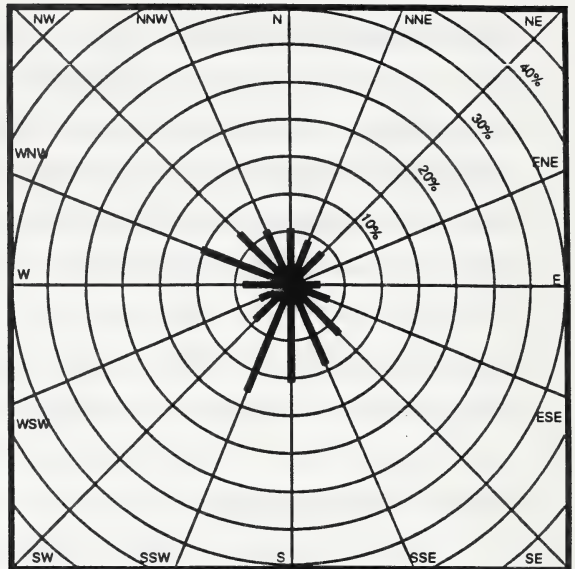
4.2.1 Results

Wind speed and direction are routinely monitored at the 10-m level at the Edmonton northwest and east, Calgary residential and industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring locations. Wind has also been monitored at the Springbank Airport, 20 km west-northwest of Calgary, since August of 1991. Wind direction frequency distributions for Edmonton and Calgary monitoring stations; and Springbank Airport, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring stations are presented in Figures 4-4 and 4-5, respectively.

Edmonton Northwest

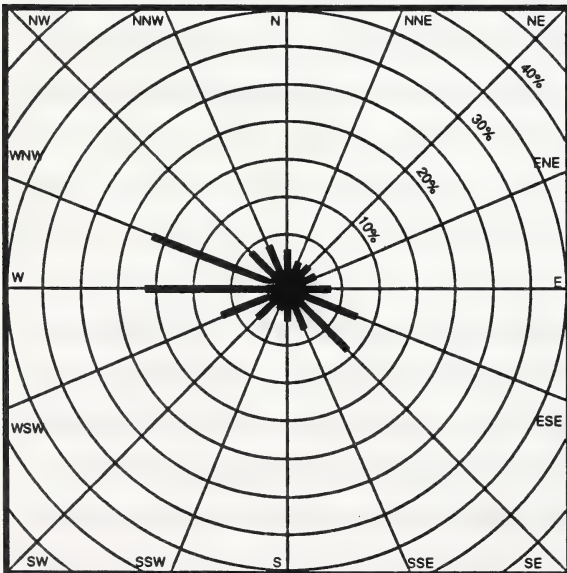
calm = 0.60%

missing = 0.00%

Edmonton East

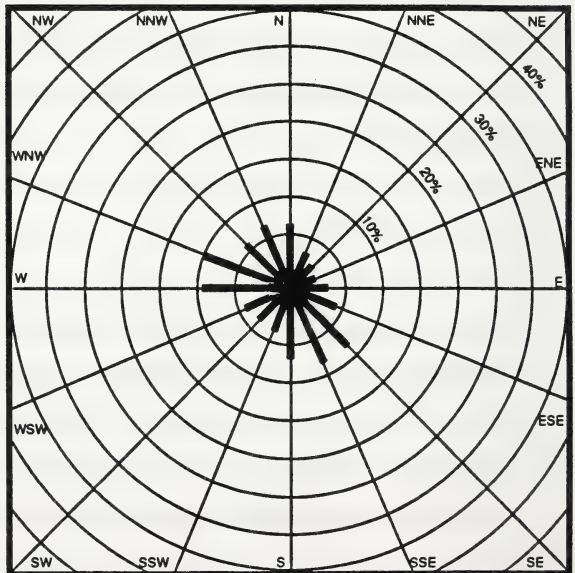
calm = 0.28%

missing = 2.09%

Calgary Residential

calm = 5.56%

missing = 0.00%

Calgary Industrial

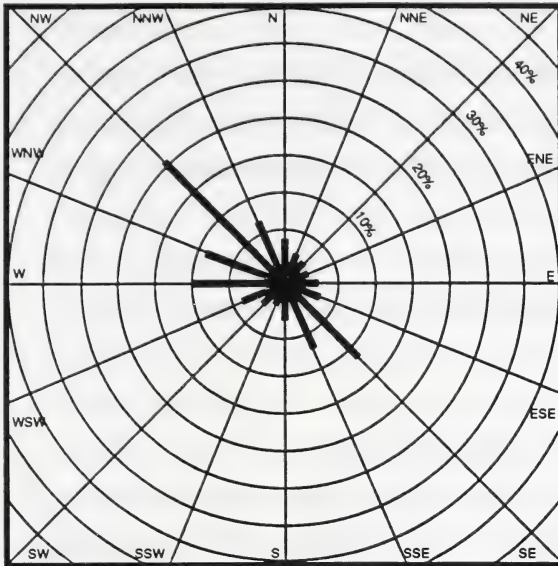
calm = 6.55%

missing = 2.69%

note: wind not monitored at Edmonton and Calgary downtown stations

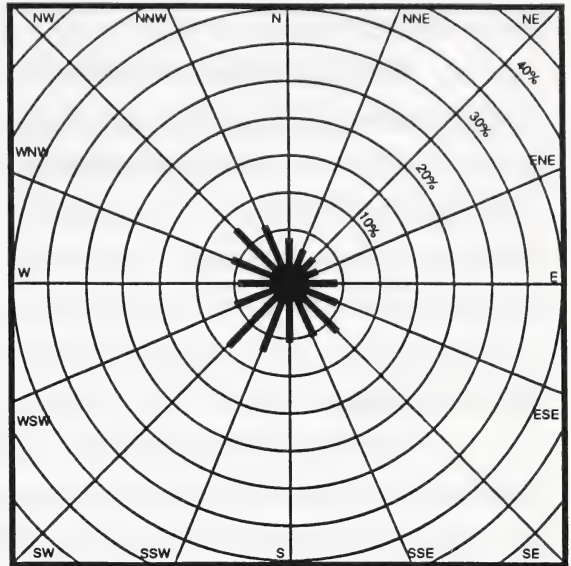
Figure 4-4 Frequency distribution of wind direction at Edmonton and Calgary monitoring locations in 1992.

ENVIRONMENTAL PROTECTION
Environmental Assessment Division
Environmental Quality Monitoring Branch

Springbank Airport

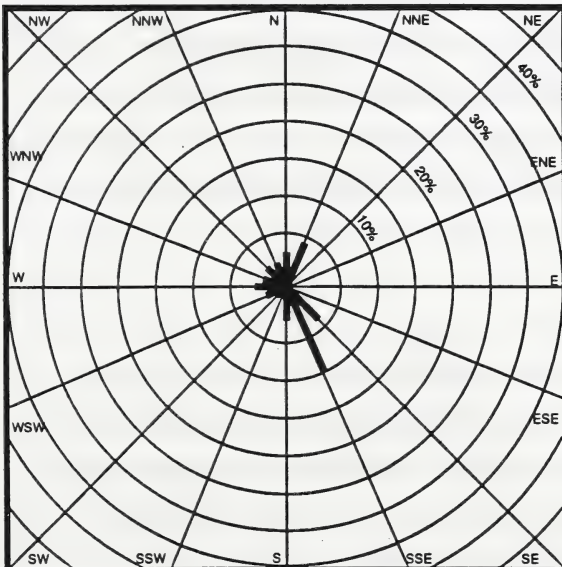
calm = 3.80%

missing = 0.05%

Fort Saskatchewan

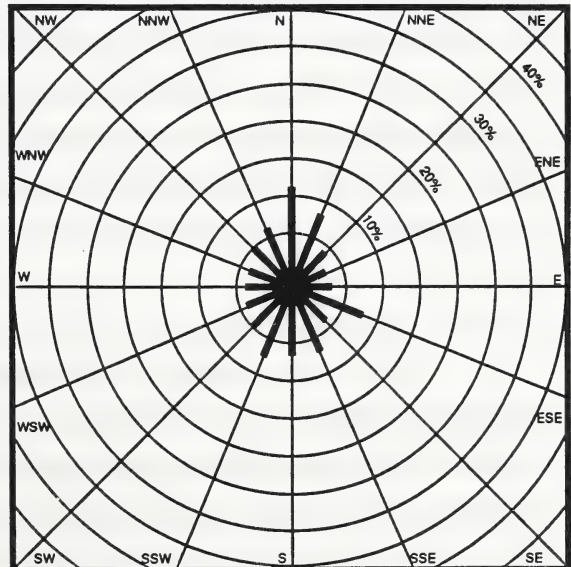
calm = 0.59%

missing = 10.52%

Fort McMurray

calm = 11.61%

missing = 48.17%

Fort MacKay

calm = 5.43%

missing = 1.38%

Figure 4-5 Frequency distribution of wind direction at Springbank Airport, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring locations in 1992.

4.2.1.1 Edmonton

Wind frequencies were distributed fairly evenly for all directions at the Edmonton northwest station in 1992. The most common wind directions at this location were west to northwest (25%) and south to south-southwest (19%). At the Edmonton east monitoring station, wind direction frequencies were less uniformly distributed with winds predominantly having a northwest and south component. Winds from the west-northwest to northwest occurred 18% of the time while about 34% of winds were from the south-southeast to south-southwest directions.

4.2.1.2 Calgary

Wind directions were primarily from the west and southeast directions at the Calgary residential monitoring station in 1992. West to west-northwest winds were observed about 34% of the time while east-southeast to southeast winds occurred 18% of the time. Wind frequencies were more evenly distributed for all directions at the industrial monitoring station with west and southeast winds being predominant. West to west-northwest winds occurred 20% of the time at the industrial location while 23% of winds were from the southeast to south directions.

A well-defined northwest/southeast orientation in the wind direction pattern is evident at the Springbank Airport (20 km west-northwest of Calgary). Winds from the west to northwest were recorded over 40% of the time at the Springbank Airport while winds from the southeast to south-southeast were observed 19% of the time.

4.2.1.3 Fort Saskatchewan

Winds were distributed fairly evenly from east to north directions at the Fort Saskatchewan monitoring station. The most common wind directions were southwest and south-southwest (17%) and west-northwest to north-northwest (21%). Wind data was not available for December at Fort Saskatchewan in 1992.

4.2.1.4 Fort McMurray

Close to half (48%) of winds at the Fort McMurray monitoring station are not available for 1992 due to either a malfunction of the instrumentation or a because of the site shutdown during renovations. The predominant winds at this location during the remainder of

the time were from the south to southeast (18%) and north to north-northeast (8%). Calm winds were recorded almost 12% of the time at the Fort McMurray monitoring station. This wind pattern reflects the location of the Fort McMurray monitoring station relative to the local topography which is defined by the Athabasca and Clearwater Rivers.

4.2.1.5 Fort MacKay

Wind directions in Fort MacKay are influenced by the Athabasca River Valley which is orientated south-north through the community. The majority of the winds at the Fort MacKay monitoring station had either a north or south component. Winds from the north-northwest to north-northeast occurred 26% of the time while south-southwest to south-southeast winds were observed 21% of the time. A relative peak in wind direction frequency was observed from the east-southeast direction (8%).

4.3 AMMONIA (NH_3)

4.3.1 Characteristics

NH_3 is a colourless gas with the well-known pungent odour found in household cleaners. NH_3 occupies a unique position as it is generally considered to be a desirable chemical, particularly in fertilizers, and not as a potential environmental pollutant. While NH_3 is produced both by natural and man-made sources, it is emitted mainly from natural sources through the decay of plant and animal material, animal waste and a small portion is released during respiration. Of all the natural sources, by far the largest is from the degradation of dead plants and animals. The other major natural source of ammonia is animal by-products.

In Alberta, the fertilizer industry is the main industrial source of NH_3 (52%). The industry produces synthetic NH_3 for either direct application to the soils as a fertilizer or as a raw material in the production of other high nitrogen fertilizer products. The other major source of NH_3 is commercial feedlots where the large amounts of animal waste can be a significant source (40%).

4.3.2 Method of Monitoring

NH₃ is monitored continuously by the same principle as NO₂. In this method the air sample is split into two pathways. In the first, all NH₃ (as well as NO₂) in the sample is converted to NO by a catalyst and high temperatures (adding to the NO already in the sample). The concentration is measured by mixing the sample with O₃ and utilizing a chemiluminescence reaction to detect the amount of visible light produced. In the second pathway, at a temperature too low to convert NH₃, NO₂ is reduced to NO by a catalytic converter (adding to the NO already in the sample) and the chemiluminescence process repeated. The difference between the two readings is then calculated to be the concentration of NH₃.

4.3.3 Regulations and Guidelines

Alberta Environmental Protection currently regulates NH₃ emissions by licencing each industrial source and limiting their emissions according to their Licence to Operate. In addition, each plant is required to monitor their emissions and report when ambient concentrations of NH₃ exceed 2.0 ppm as a 1-hour average.

4.3.4 Results

4.3.4.1 Fort Saskatchewan

NH₃ is monitored by Alberta Environmental Protection at the Fort Saskatchewan monitoring station because of its proximity to the fertilizer industry. Figure 4-6 shows the frequency distribution of NH₃ concentrations by month and annual average concentrations. Ammonia data is only available for February and March at Fort Saskatchewan in 1992 due to instrument malfunction (for January and from April to November) and relocation of the monitoring station (in December). The maximum ammonia concentration during this monitoring period was 0.7 ppm. This compares the ambient guideline of 2.0 ppm. The overall average ammonia concentration at the Fort Saskatchewan monitoring station during February and March was 0.01 ppm. Ambient 1-hour ammonia concentrations were below the detection limit of the instrument close to 90% of the time during the monitoring period.

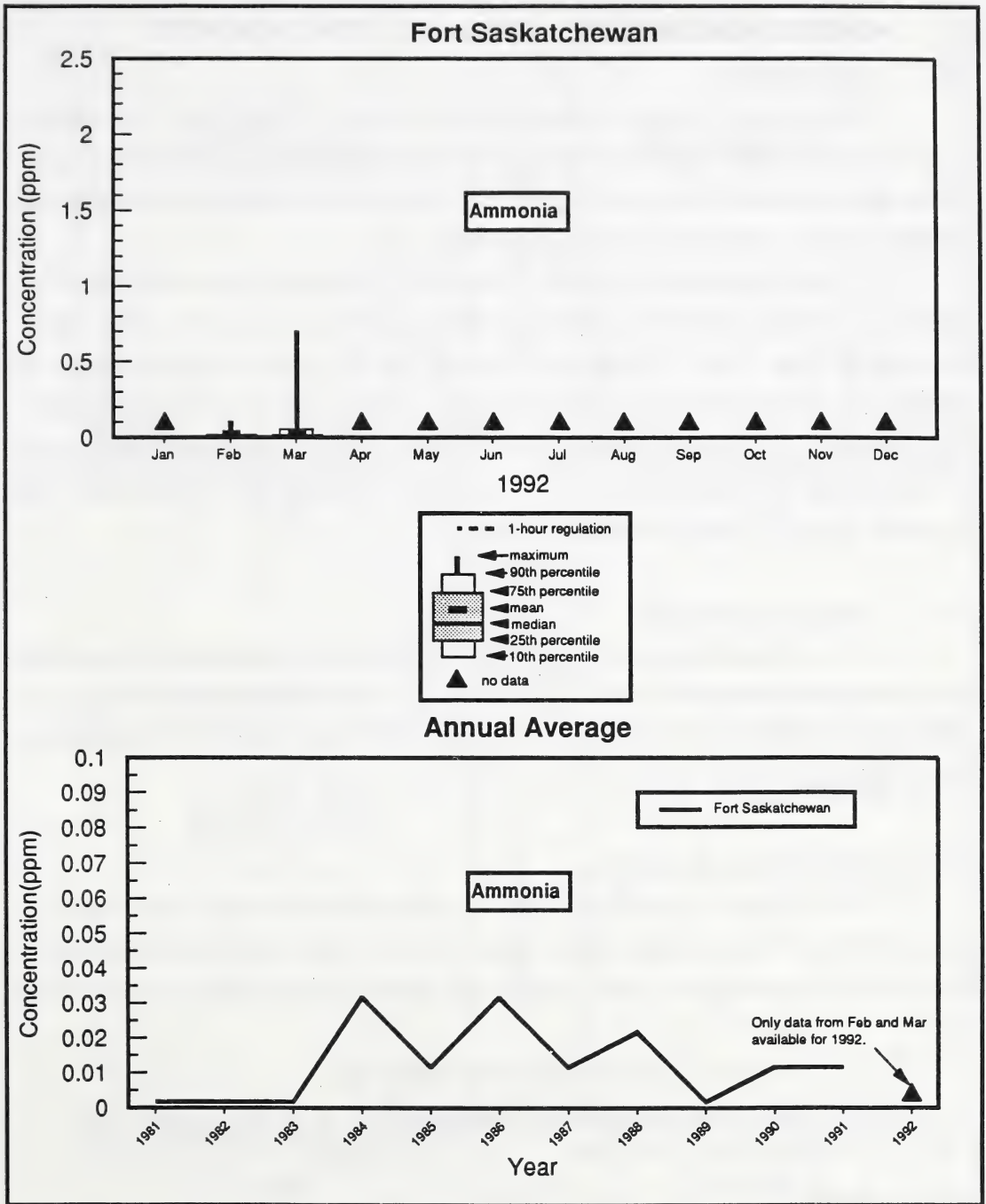


Figure 4-6 Frequency distribution of ammonia concentrations at Fort Saskatchewan.

4.4 CARBON MONOXIDE (CO)

4.4.1 Characteristics

CO, a common pollutant in urban areas, is a colourless, odourless gas. The majority of the CO found in urban air comes from incomplete combustion of carbon-based fuels. The primary source of urban CO is motor vehicles, with much smaller contributions from fireplaces, industrial sources, aircraft and natural gas combustion.

The relationship between vehicular traffic and CO is apparent at urban locations during morning and evening rush hours. CO concentrations also fluctuate seasonally. The highest concentrations occur during the late autumn, winter and early spring primarily because of meteorological conditions, such as stable atmospheric conditions and low wind speeds result in decreased pollutant dispersion. Other factors which contribute to higher concentrations during the autumn and winter are: (1) in cold weather, motor vehicles run less efficiently; and (2) vehicle warmup and idling times are increased.

4.4.2 Method of Monitoring

CO is monitored continuously by either non-dispersive infrared photometry or gas filter correlation. The non-dispersive infrared photometry process is based upon the absorption of infrared light by CO. Gas filter correlation is operated on the same principle as non-dispersive infrared photometry and is also based on the absorption of energy by CO.

4.4.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of CO are based on the prevention of human health effects. In regulating CO, Alberta has adopted Environment Canada's most rigorous ambient air quality regulations. Maximum permissible CO concentrations are:

- ▲ 13.0 ppm as a 1-hour average concentration; and
- ▲ 5.0 ppm as an 8-hour average concentration.

4.4.4 Results

CO was monitored, on a continuous basis, at all three Edmonton and Calgary air quality stations, and at the Fort Saskatchewan and Fort McMurray monitoring stations. Frequency distributions of monthly CO concentrations and annual average CO concentrations are illustrated in Figures 4-7 to 4-9.

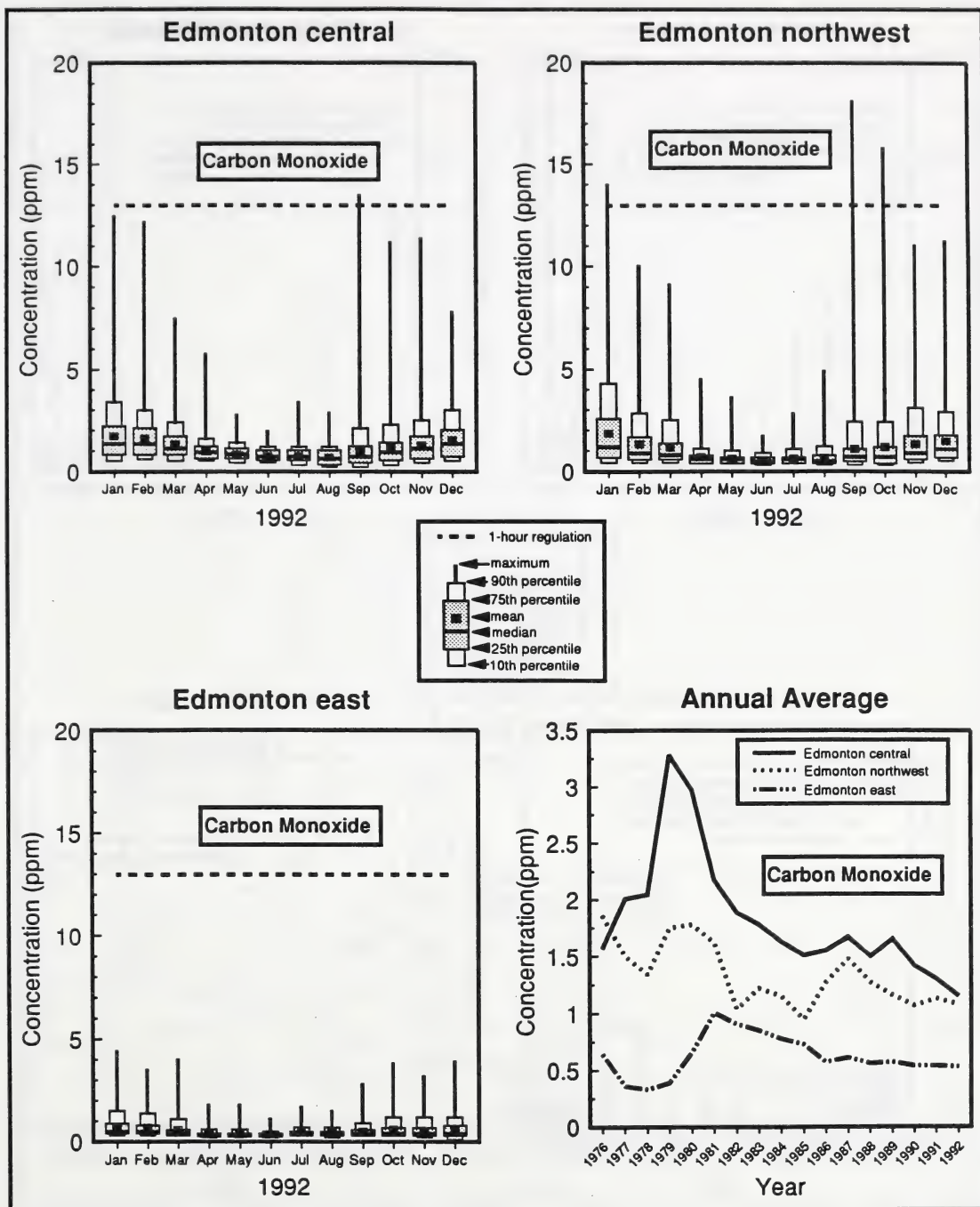


Figure 4-7 Frequency distribution of carbon monoxide concentrations at Edmonton.

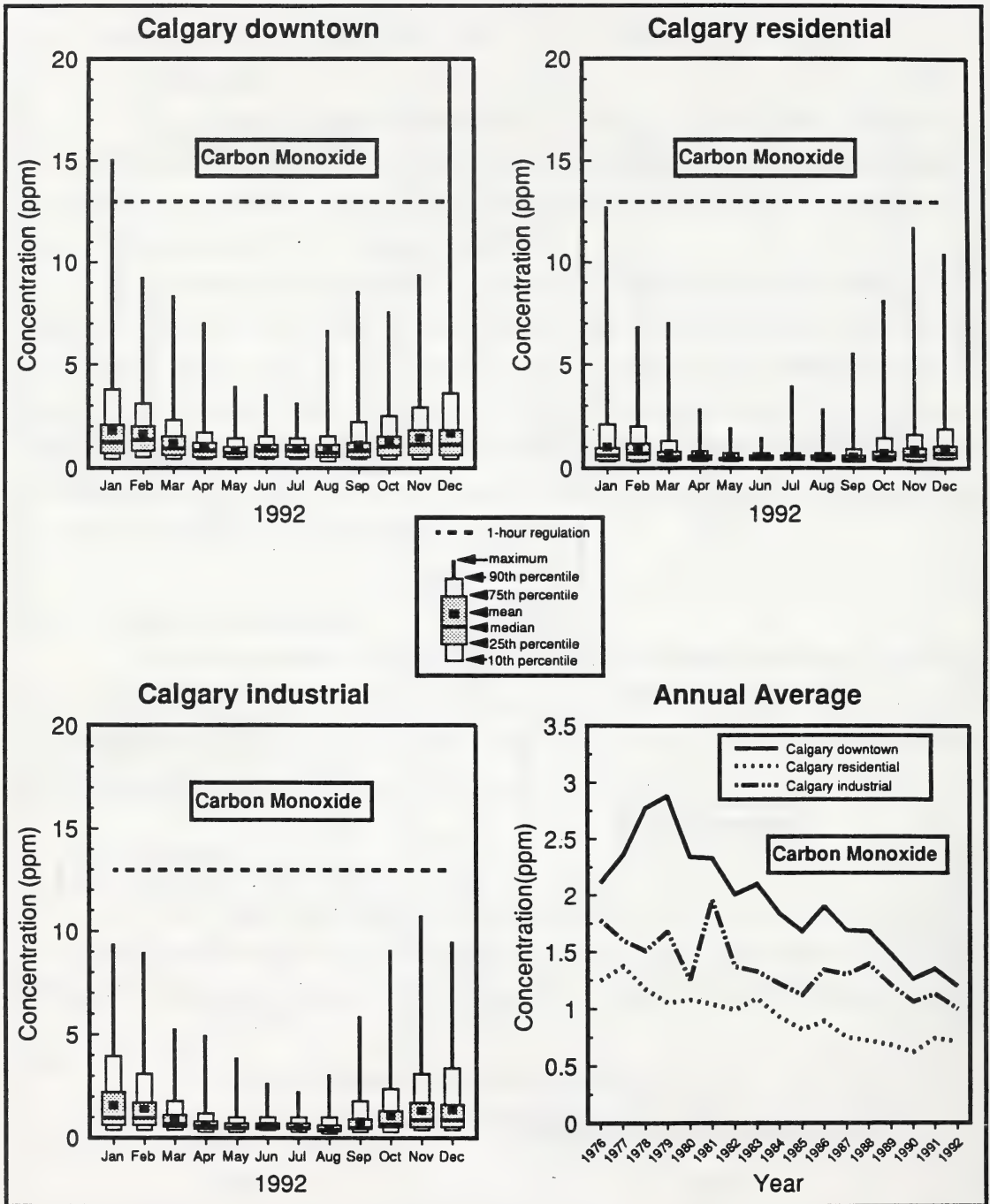


Figure 4-8 Frequency distribution of carbon monoxide concentrations at Calgary.

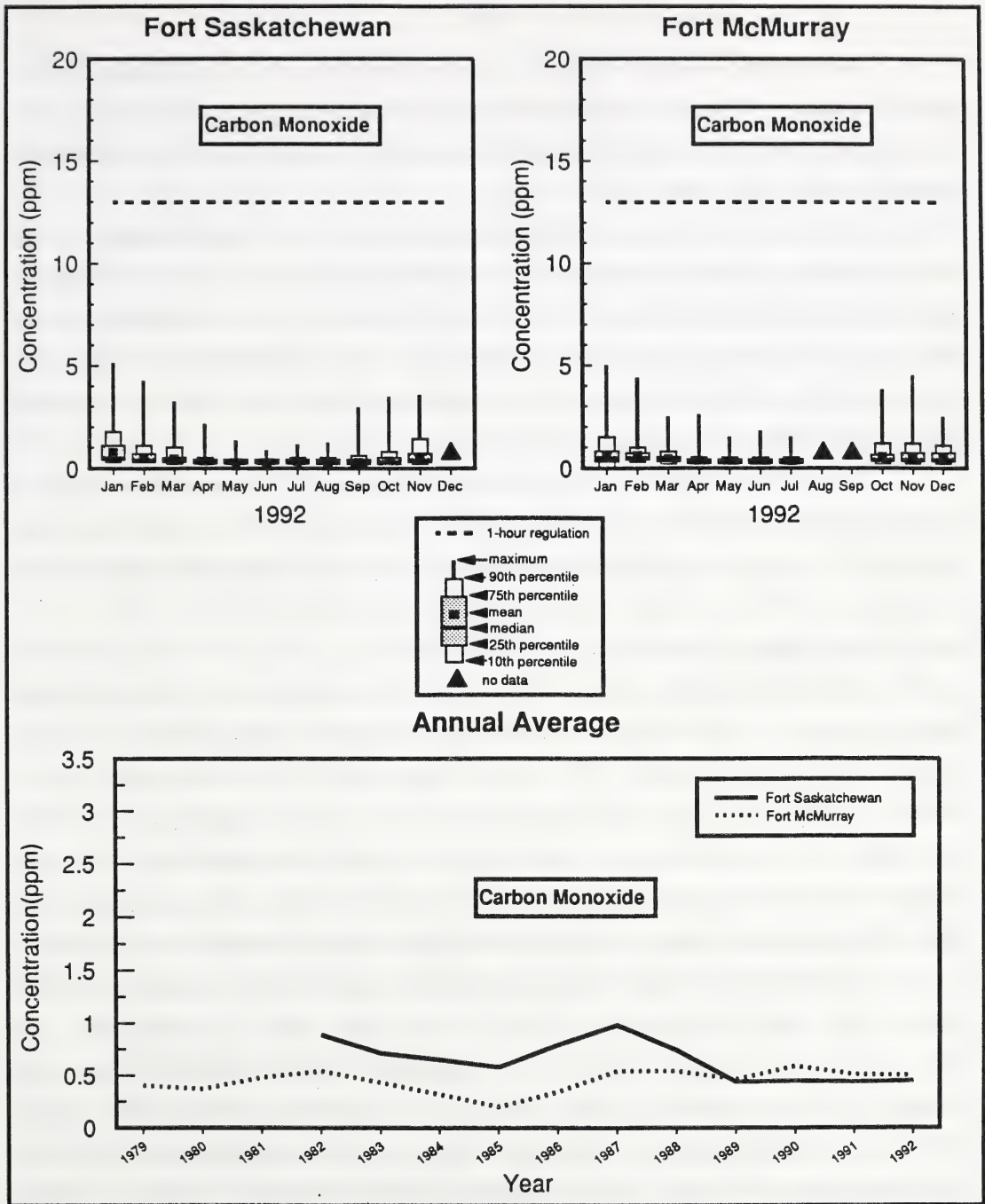


Figure 4-9 Frequency distribution of carbon monoxide concentrations at Fort Saskatchewan and Fort McMurray.

On an annual average basis, CO concentrations ranged from 0.45 ppm at Fort Saskatchewan to 1.20 ppm in downtown Calgary. Relatively high annual average CO concentrations were also evident at the Edmonton central, Edmonton northwest and Calgary industrial monitoring locations.

CO concentrations are generally higher in the autumn and winter months than the spring and summer months. In the winter, temperature inversions are more likely to persist throughout the day due to a lack of solar heating. Persistent inversions coupled with longer vehicular warmup and idling times lead to increased CO concentrations during the late autumn and winter months. Most strong temperature inversions in Calgary occur prior to a chinook. Mixing will increase once warm air from the chinook reaches ground-level.

A well-defined diurnal variation of CO concentrations was evident at most air quality monitoring stations. CO peaks were evident during the morning and afternoon traffic rush hours. The lowest CO values were generally recorded overnight when vehicular traffic is at a minimum.

4.4.4.1 Edmonton

Exceedances of the 1-hour regulation for CO were recorded at the central and northwest stations in 1992. A total of one and nine exceedances of this regulation were recorded at these two locations, respectively. The 8-hour average regulation was exceeded six times at the central station and 15 times at the northwest station. The overall maximum concentrations at the central, northwest and east stations were 13.5, 18.1 and 4.4 ppm, respectively. These peak values were recorded in September at the central and northwest stations and in January at the east station. Wind directions during exceedance episodes at the northwest station were predominantly from the south-southwest to south-southeast directions. A major traffic artery (132 Avenue) is located to the south of this station and likely is the major source of exceedances. CO concentrations were consistently higher at the central and northwest monitoring stations as compared to the east monitoring station because of their proximity to major traffic arteries. Based on 17 years of data, a downward trend in annual average CO concentrations is evident at Edmonton central and northwest monitoring stations. This trend is likely due to more efficient automobile engines.

4.4.4.2 Calgary

Exceedances of the 1-hour regulation for CO were recorded for three hours at the Calgary downtown station in 1992. These exceedances were recorded in January and December. Peak 1-hour CO values were 20.2, 12.7, and 10.7 ppm at the downtown, residential and industrial stations, respectively. A total of nine, four and two hours exceeded the 8-hour regulation for CO at these stations, respectively. All of these exceedances were recorded in the late fall or winter months. The overall maximum 8-hour average CO concentrations at the downtown, residential and industrial monitoring locations were 8.8, 5.6 and 5.4 ppm, respectively. A significant downward trend in the annual average concentration of CO is evident at all Calgary monitoring stations based on 17 years of data. This trend may be due to decreased vehicular emissions of CO because of more efficient automobile engines.

4.4.4.3 Fort Saskatchewan

The 1- and 8-hour regulations for CO were not exceeded at the Fort Saskatchewan monitoring unit in 1992. Peak 1- and 8- hour average CO concentrations were 5.1 and 3.4 ppm, respectively. A significant downward trend in annual average CO concentrations is evident based on 11 years of data at the Fort Saskatchewan monitoring location.

4.4.4.4 Fort McMurray

Exceedances of the 1- and 8-hour regulations were not observed at the Fort McMurray monitoring unit in 1992. Maximum 1- and 8-hour average values for CO of 5.0 and 3.3 ppm, respectively, were observed in January at the Fort McMurray monitoring station. Annual average CO data collected at Fort McMurray does not show a significant historical trend.

4.5 CARBON DIOXIDE (CO₂)

4.5.1 Characteristics

CO₂ is a colourless, odourless, non-toxic gas that is produced during the combustion of carbon containing compounds. CO₂ is absorbed by trees and other vegetation through photosynthesis and some CO₂ re-emitted to the atmosphere by plants, animals and micro-organisms through respiration.

Increasing atmospheric CO₂ concentrations on a global level have been suggested to be a major contributor to an enhanced greenhouse effect. Solar radiation passes through the atmosphere and is absorbed by the earth's surface. Heat is then re-radiated by the earth's surface into the atmosphere. Greenhouse gases such as CO₂ absorb this reflected heat and thus warm the atmosphere. Heat is essentially trapped in the atmosphere by greenhouse gases such as CO₂. Without this natural greenhouse effect, life as we know it would not exist on earth. Man-made emissions of CO₂ increase global concentrations of CO₂ and enhance this greenhouse effect contributing to additional heating of the atmosphere. Carbon dioxide makes up over half of emissions of greenhouse gases by man. Other greenhouse gases include methane, chlorofluorocarbons, nitrous oxide and ozone.

Approximately 124.3 megatonnes of CO₂ were emitted in Alberta in 1988. This is about 22% of total CO₂ emissions for Canada. In 1988, the energy sector was responsible for 42% of CO₂ emissions in Alberta while fuel combustion by the commercial (commercial buildings) and residential sectors (houses, apartments and business) each contributed 12% of total CO₂ emissions. Transportation and other industries comprised about 32% of CO₂ emissions for Alberta in 1988 (Alberta Energy 1990).

4.5.2 Method of Monitoring

Carbon dioxide is monitored continuously by non-dispersive infrared photometry. This detection process is based on the absorption of infrared light by CO₂.

4.5.3 Regulations and Guidelines

At the present time, Alberta Environmental Protection does not have regulations or guidelines for ambient concentrations of CO₂.

4.5.4 Results

Monitoring for CO₂ by Alberta Environmental Protection began at the Calgary downtown monitoring station in March of 1991. An additional station was added at Springbank, approximately 20 km west-northwest of downtown Calgary, in August of 1991. This station was

added to monitor CO₂ concentrations upwind of Calgary. Figure 4-10 shows the frequency distribution of CO₂ concentrations at the Calgary downtown and Springbank monitoring sites.

4.5.4.1 Calgary

Annual average CO₂ concentrations at the downtown and Springbank monitoring stations were 391 and 371 ppm, respectively. Average CO₂ concentrations were above those observed at Crossfield, about 40 km north of Calgary, and Fortress Mountain, about 85 km west-southwest of Calgary during the Acid Deposition Research Program. Annual average concentrations observed at these locations ranged from 345 to 349 ppm (Legge 1988). Higher CO₂ concentrations in downtown Calgary are due to heating fuel and gasoline combustion in Calgary and the surrounding area.

Overall maximum 1-hour average CO₂ concentrations at the downtown and Springbank monitoring stations were 606 and 555 ppm, respectively. The highest CO₂ concentrations were generally observed in the late fall, winter and early spring at the downtown monitoring station. The highest concentrations at the Springbank site were recorded in June, July and August.

4.6 COEFFICIENT OF HAZE (COH)

4.6.1 Characteristics

The interaction of particles with sunlight and atmospheric moisture can result in diminished visibility (haze). The coefficient of haze is an indicator which corresponds to the reduction of transmitted light, or visibility reduction, due to particulate matter in the form of dust and smoke. Sources of dust and smoke include motor vehicle emissions, industrial emissions, road dust, wind blown soil, dust resulting from other human activities (i.e., agriculture), smoke from forest fires, and smoke from recreational sources (i.e., camp fires and fireplaces).

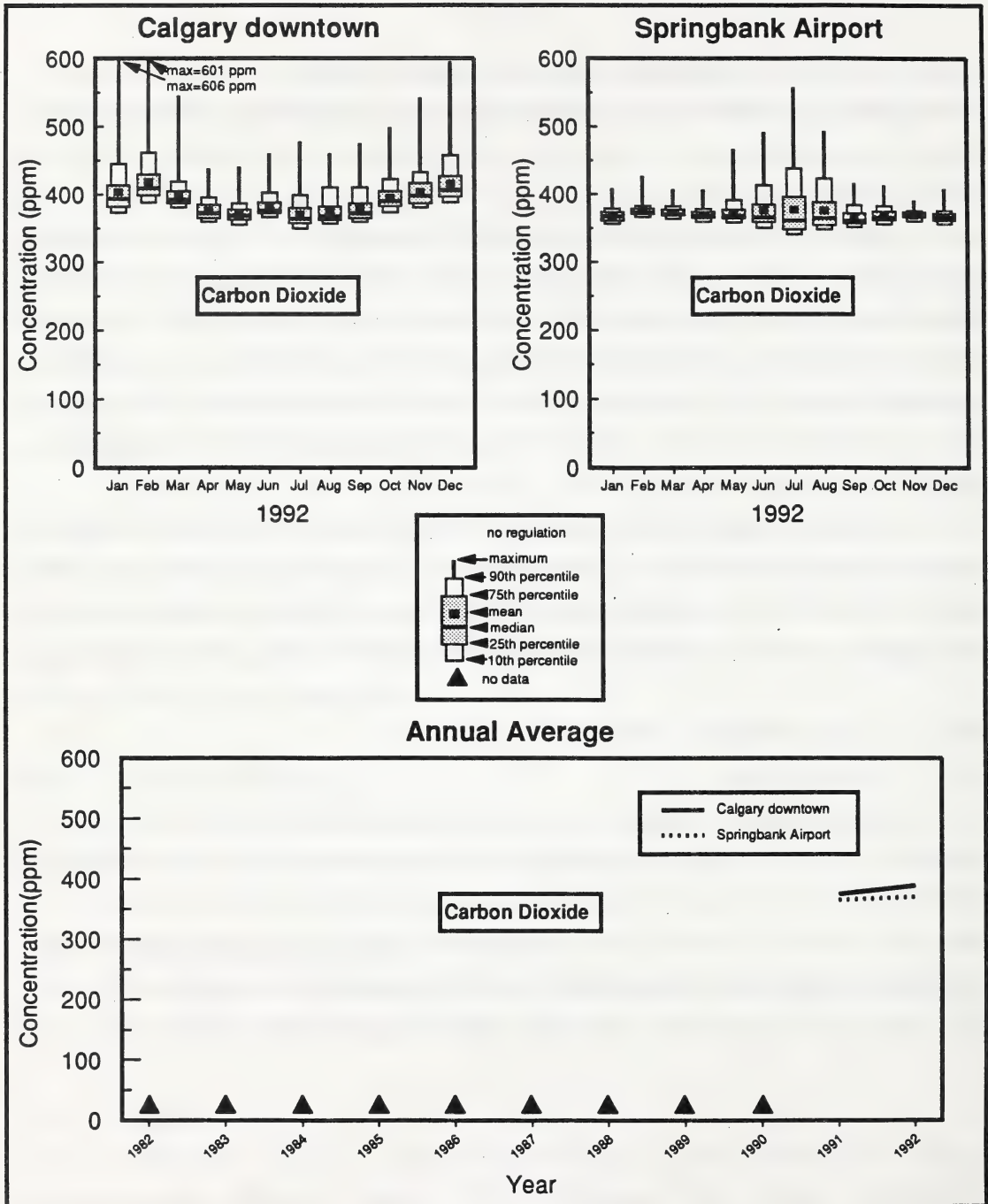


Figure 4-10 Frequency distribution of carbon dioxide concentrations at Calgary.

4.6.2 Method of Monitoring

Air samples are collected continuously by drawing a known volume of air through a filter paper for a period of one hour. The soiling properties of the sample are measured by the reduction of light transmission through the filter tape. This reduction is reported as the coefficient of haze per 1000 linear feet of air sample. This method does not measure the absolute concentration or deposited mass of particulates but rather is an index of fine suspended particulate matter in the air.

4.6.3 Regulations and Guidelines

Guidelines regarding the COH are based on visibility reduction. Alberta Environmental Protection has established that:

- ▲ 90% of the COH readings per month shall be less than 1.0 COH unit.

4.6.4 Results

The COH was monitored at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring units. Annual average COH indices ranged from 0.06 COH units at the Calgary residential station to 0.23 COH units at the Edmonton northwest, Edmonton east and Calgary industrial stations. Relatively high annual average values were also recorded at the Edmonton central (0.21 COH units) and Calgary downtown (0.18 COH units) locations. Higher annual average COH values were evident at locations close to major traffic arteries or industrial sources.

A seasonal trend indicating higher COH levels during the winter and autumn seasons is obvious at most stations. Meteorological conditions in the winter and autumn months are often favourable for the accumulation of pollutants within the lower atmosphere. The major sources of dust and smoke in urban areas are dust from the streets (especially in the winter and early spring), vehicular emissions and industrial emissions.

At stations which are located in the vicinity of major traffic arteries (all Edmonton stations and Calgary downtown and industrial stations), substantial maximums in COH values were recorded during the morning and afternoon rush hours. This diurnal tendency is not as prevalent at Fort Saskatchewan and Fort McMurray, where vehicular emissions are somewhat

lower than Edmonton and Calgary. Frequencies of monthly COH values and are presented in Figures 4-11 to 4-13. The trends of annual average COH values are also illustrated in these figures.

4.6.4.1 Edmonton

The guideline for COH (90% of COH values per month must be less than 1.0 COH unit) was not exceeded at any Edmonton monitoring stations in 1992. The highest frequency of values above 1.0 COH unit were 8.9% and 8.8% which were recorded in January at the northwest and east monitoring stations, respectively. A maximum 1-hour average COH value of 4.5 COH units was observed in September at the northwest monitoring station. A significant increase in annual average COH values is evident at the Edmonton east monitoring station based on 17 years of data.

4.6.4.2 Calgary

The guideline for COH was not exceeded at any Calgary monitoring stations in 1992. The maximum frequency of COH values greater than 1.0 COH units was 8.1% which was recorded in January at the industrial monitoring station. An overall maximum 1-hour average COH value of 3.8 COH units was recorded in January at the industrial station. A significant long-term downward trend in annual average COH values was observed at the Calgary residential monitoring location.

4.6.4.3 Fort Saskatchewan

The highest monthly frequency of COH values greater than 1.0 COH unit was 2.2% which occurred in January at the Fort Saskatchewan monitoring station. The overall maximum COH value was 1.5 COH units which was recorded in December. The guideline for COH was not exceeded at the in Fort Saskatchewan in 1992. A slight downward trend in annual average COH is evident at the Fort Saskatchewan monitoring station.

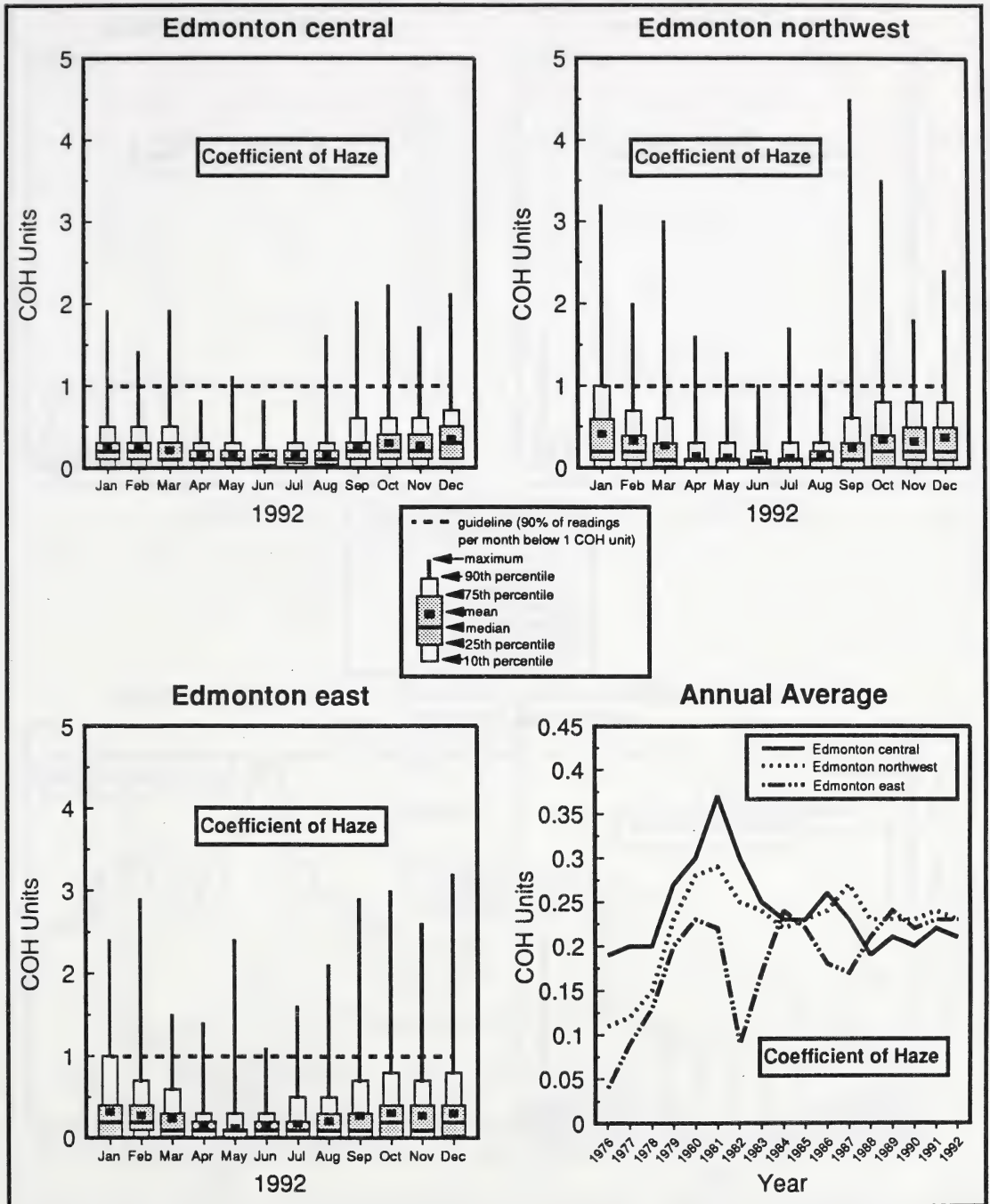


Figure 4-11 Frequency distribution of coefficient of haze values at Edmonton.

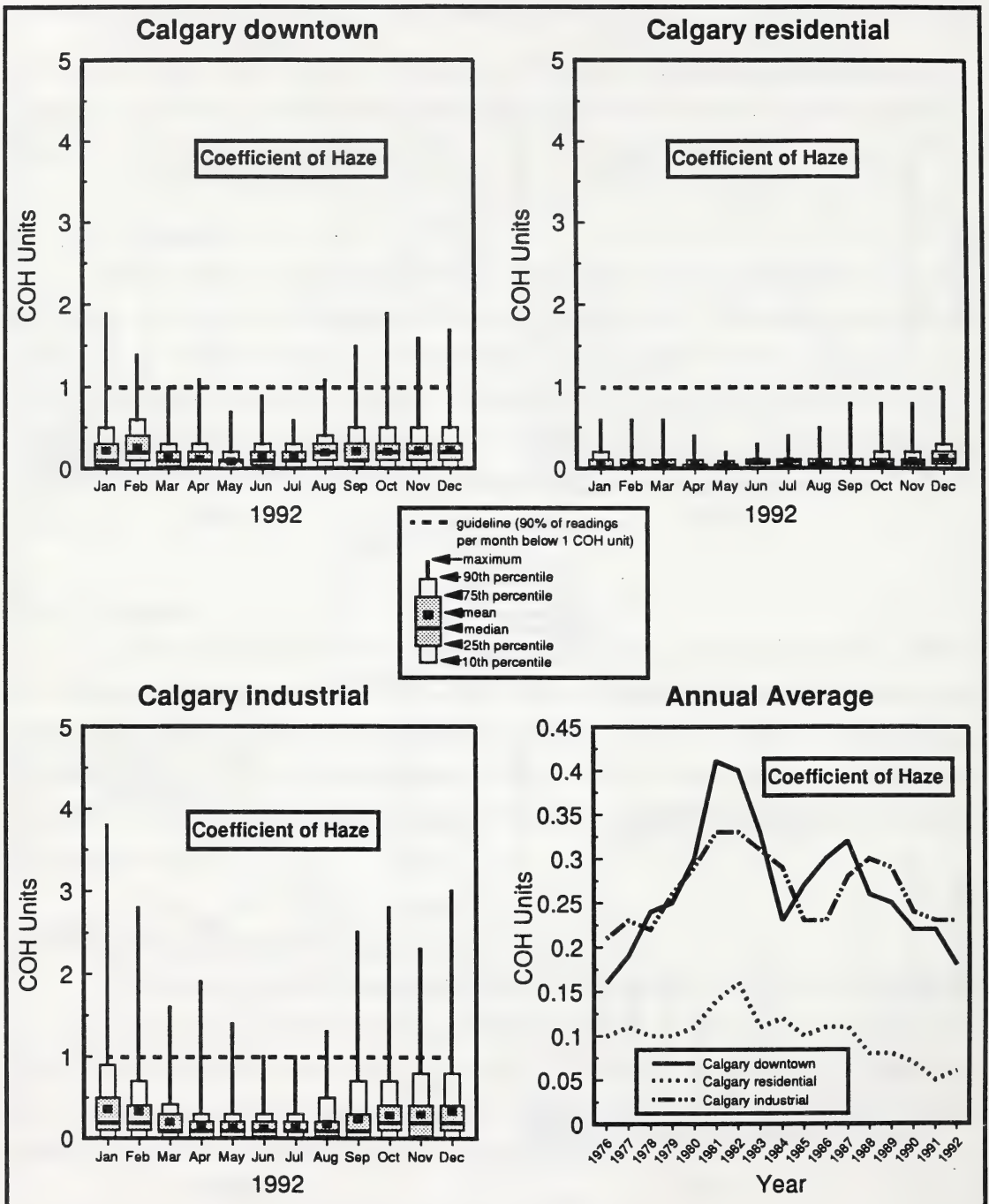


Figure 4-12 Frequency distribution of coefficient of haze values at Calgary.

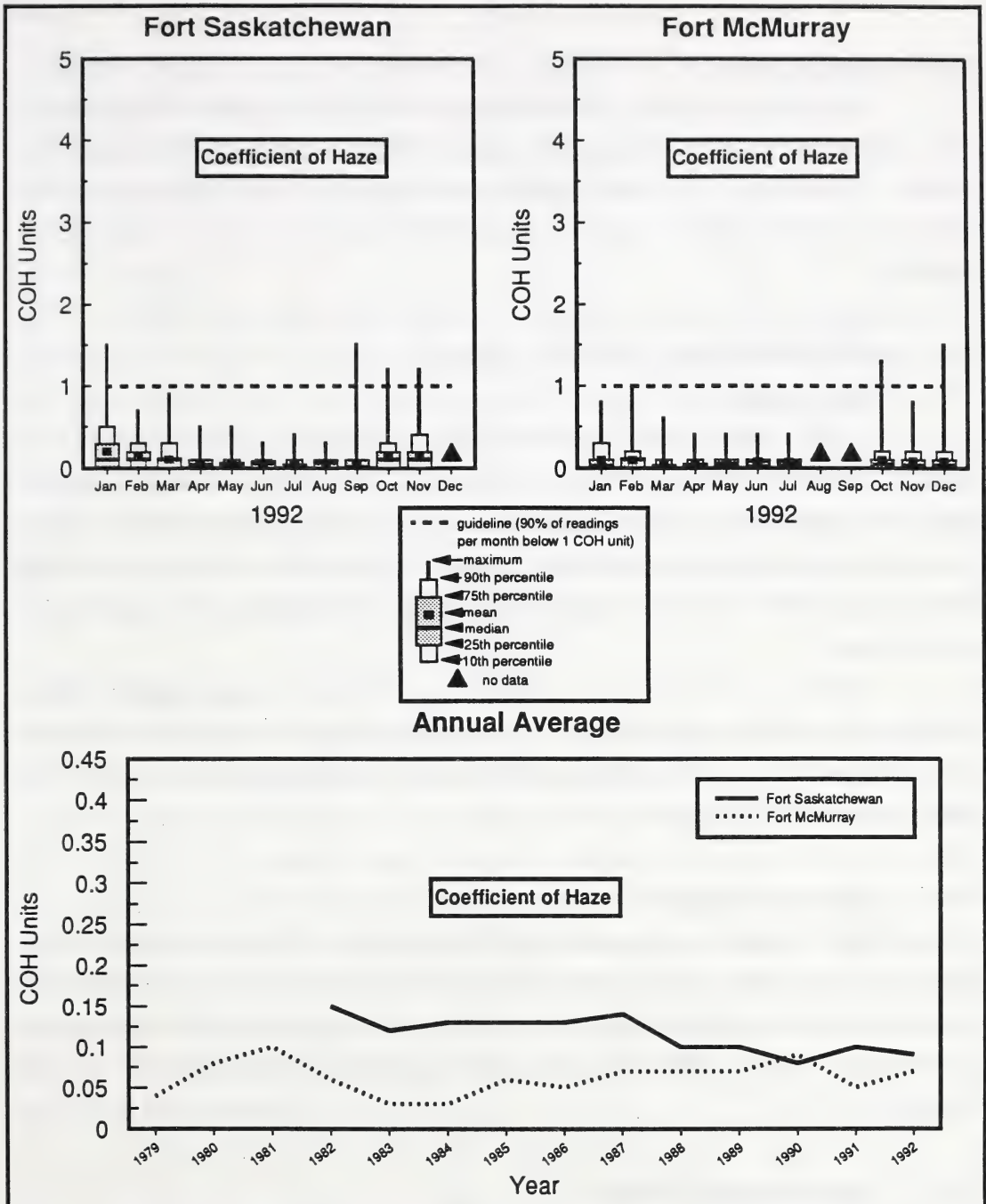


Figure 4-13 Frequency distribution of coefficient of haze values at Fort Saskatchewan and Fort McMurray.

4.6.4.4 Fort McMurray

The guideline for COH was not exceeded at the Fort McMurray monitoring station in 1992. The highest frequency of values greater than 1.0 COH units was 0.2% which occurred in October. A maximum COH value of 1.5 COH units was recorded in December at the Fort McMurray monitoring station. Annual average COH values do not show a trend at Fort McMurray.

4.7 HYDROGEN SULPHIDE (H₂S)

4.7.1 Characteristics

H₂S is a colorless gas with a characteristic rotten egg odour. H₂S is produced both naturally and through industrial processes. H₂S is found naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. It is also produced under anaerobic conditions in the decomposition of sulphur-containing bacteria. Decomposition of sulphur-containing bacteria is responsible for the rotten egg odour commonly associated with marshes, sewers, and sewage lagoons.

While most of the H₂S in the atmosphere is from natural sources, industrial sources have a significant impact on the environment. These industrial sources are primarily petroleum refining, natural gas plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process.

4.7.2 Method of Monitoring

H₂S is measured continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any H₂S in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the H₂S concentration.

4.7.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of H₂S is based on the odour threshold although, many individuals can smell H₂S at levels below the ambient

regulations. In regulating H₂S, Alberta has adopted Environment Canada's most rigorous ambient regulation with a maximum permissible concentration of:

- ▲ 0.010 ppm as a 1-hour average concentration; and
- ▲ 0.003 ppm as a 24-hour average concentration.

4.7.4 Results

H₂S is monitored at the Edmonton east, Calgary industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring units. Percentile diagrams for monthly concentrations and annual average concentrations from these stations are presented in Figures 4-14 to 4-16.

Annual average H₂S concentrations were 0.001 ppm at the Edmonton east, Calgary industrial and Fort Saskatchewan monitoring locations. All other stations recorded a value below the limit of detection as an annual average. Since H₂S concentrations were low at most locations, seasonal, diurnal and annual trends were not distinguishable, however, episodic exceedances of the regulations were observed.

4.7.4.1 Edmonton

A total of 11 exceedances of the 1-hour regulation for H₂S were reported at the Edmonton east monitoring station in 1992. This is compared to 59 exceedances of the 1-hour regulation at this location in 1991. Exceedances of this regulation were recorded in January, February, May, October and December. The overall maximum 1-hour average H₂S concentration was 0.035 ppm which was recorded in December. Over half (54%) of the wind directions were from the south-southeast to south-southwest during exceedance episodes. The remaining exceedances were recorded when winds were from the north-northeast to east-northeast. The majority of these exceedances are likely caused by fugitive emissions from local industrial sources. Exceedances of the 24-hour regulation for H₂S were not recorded at the Edmonton east monitoring station in 1992.

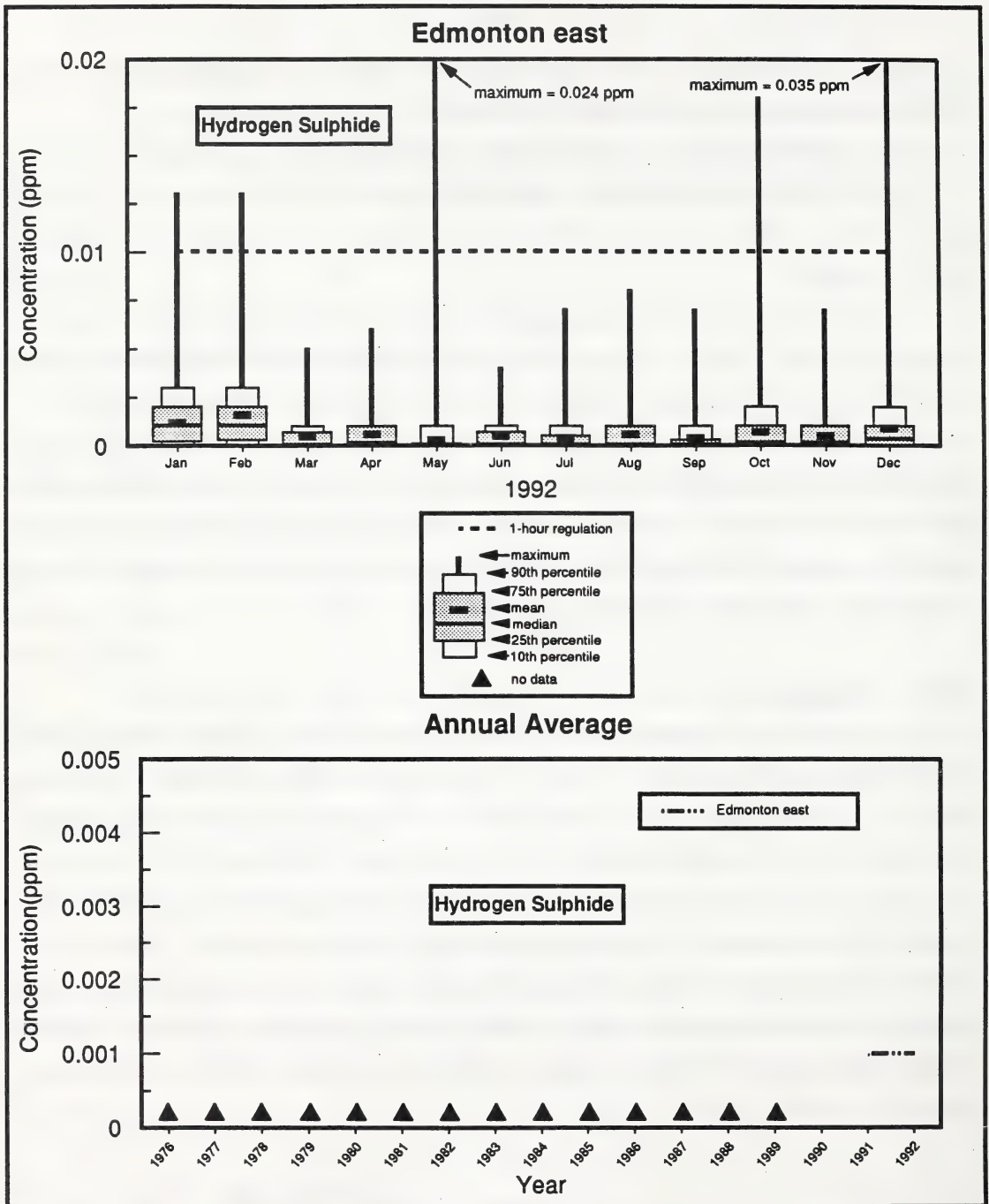


Figure 4-14 Frequency distribution of hydrogen sulphide concentrations at Edmonton.

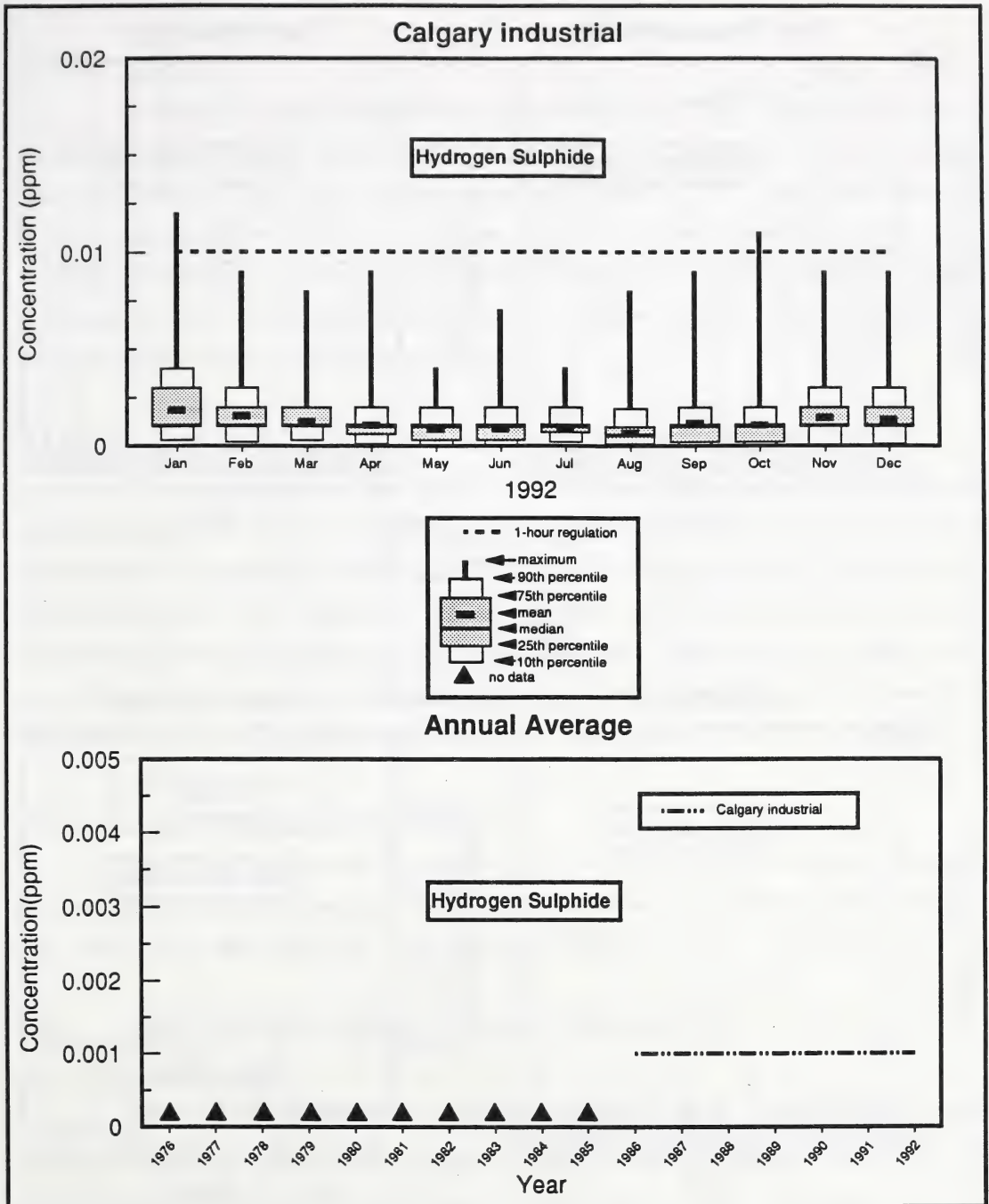


Figure 4-15 Frequency distribution of hydrogen sulphide concentrations at Calgary.

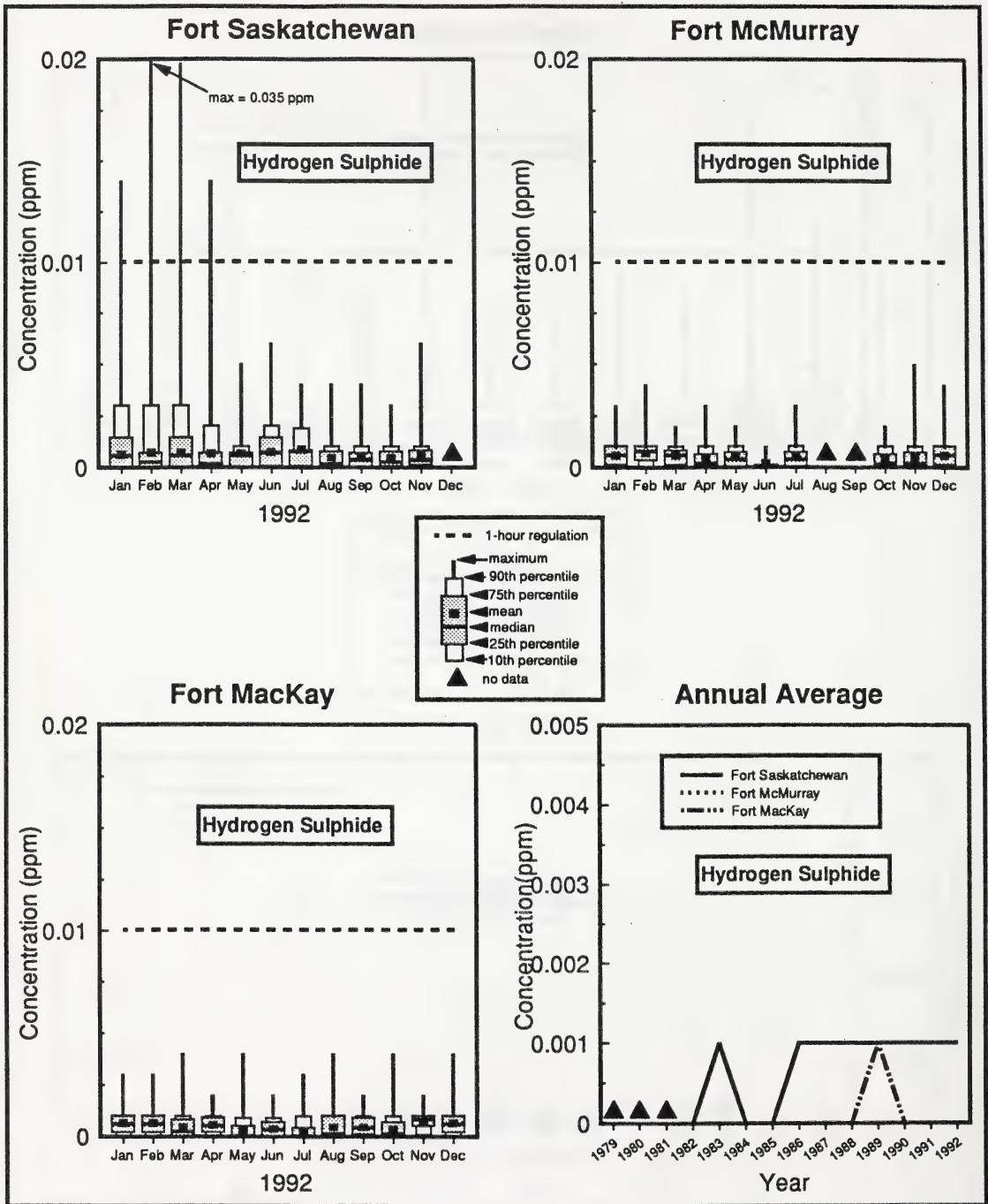


Figure 4-16 Frequency distribution of hydrogen sulphide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

4.7.4.2 Calgary

A total of 4 hours exceeded the 1-hour regulation for H_2S at the Calgary industrial monitoring station. These exceedances occurred in January and October. The 24-hour regulation was not exceeded at the Calgary industrial monitoring station in 1992. The overall maximum 1-hour concentration was 0.012 ppm which was recorded in January. Exceedances of the 1-hour regulation were when winds were from the north, southwest and west directions. Wind speeds were generally very low during exceedance episodes. Sources of H_2S in southwest Calgary are primarily fugitive emissions from local industry.

4.7.4.3 Fort Saskatchewan

The 1-hour regulation for H_2S was exceeded 13 times at the Fort Saskatchewan monitoring station in 1992. These exceedances were recorded from January to April with the highest number (9 exceedances) observed in February. The 24-hour regulation was exceeded for two times (January and February). The maximum 1-hour and 24-hour average H_2S concentrations were 0.035 ppm and 0.004 ppm, respectively. Winds during exceedance times were primarily from the south-southwest to west-southwest and north to north-northeast directions. Sources of H_2S in the region are likely fugitive emissions from local industry.

4.7.4.4 Fort McMurray and Fort MacKay

The 1-hour and 24-hour regulations for H_2S were not exceeded at the Fort McMurray or Fort MacKay monitoring stations in 1992. Maximum 1-hour concentrations at Fort McMurray and Fort MacKay were 0.005 and 0.004 ppm, respectively.

4.8 OXIDES OF NITROGEN (NO_2 , NO and NO_x)

4.8.1 Characteristics

Oxides of nitrogen appear in the ambient atmosphere as nitrogen dioxide (NO_2), nitric oxide (NO) and nitrous oxide (N_2O). Alberta Environmental Protection monitors for NO_2 , NO, and NO_x on a continuous basis.

During high temperature combustion, as in the burning of natural gas, coal, oil and gasoline, atmospheric nitrogen may combine with molecular oxygen to form NO. NO is

colourless, odourless and has no known toxic effects. Most of the NO is rapidly oxidized to form NO₂. NO₂ is a reddish-brown gas with a characteristic pungent odour. NO₂ is partially responsible for the brownish discolouration of the lower atmosphere near urban areas.

Nitrous oxide is a naturally occurring, sweet smelling, non-toxic gas in the ambient atmosphere. For the purposes of air quality monitoring, total oxides of nitrogen (NO_x) is considered to be the sum of the concentration of NO₂ and NO. Nitrous oxide is not included as a contributor to total oxides of nitrogen in ambient air quality monitoring because ambient concentrations are generally very low.

In Alberta, about 38% of NO_x emissions are contributed by the oil and gas industry, 29% by transportation and 16% by power plants. The remaining 17% originate from natural gas and heating fuel combustion, agricultural fuel consumption and other industries (Alberta Environment 1990).

4.8.2 Method of Monitoring

Oxides of nitrogen are measured continuously by the principle of chemiluminescence. In this method, the air sample is split into two pathways. In the first pathway, the NO concentration is measured by mixing ozone with the sample and detecting the amount of visible light produced when NO reacts with O₃ to form NO₂. In the second pathway, all the NO₂ in the sample is reduced to NO by a catalytic converter adding to the NO already present. The total NO_x is measured by reacting all the NO in the second pathway with ozone. The difference between the two readings is the concentration of NO₂.

4.8.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of NO₂ are based on the prevention of human health effects. In regulating NO₂, Alberta has adopted the most rigorous ambient regulations set by Environment Canada with a maximum average concentration of:

- ▲ 0.21 ppm as a 1-hour average concentration;
- ▲ 0.11 ppm as a 24-hour average concentration; and
- ▲ 0.03 ppm as an annual arithmetic average.

There are no regulations for ambient concentrations of NO and NO_x.

4.8.4 Results

NO_2 , NO and NO_x are monitored routinely at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring sites. Figures 4-17 to 4-19 show monthly frequency distributions for NO_2 at each monitoring location. Annual average concentrations are also presented in these figures.

Annual average NO_2 concentrations ranged from 0.009 ppm at Fort McMurray to 0.032 ppm at the Calgary downtown monitoring unit. The Edmonton central (0.026 ppm) and Calgary industrial (0.025 ppm) monitoring stations also recorded relatively high annual average NO_2 concentrations. Higher NO_2 concentrations at these locations were mainly due to a higher density of vehicular traffic and also the usage of heating fuels.

Frequency distributions NO concentrations are shown in Figures 4-20 to 4-22 on a monthly basis. NO concentrations ranged from 0.010 ppm at Fort McMurray to 0.049 ppm at the Calgary industrial monitoring station based on annual average values. A relatively high NO concentration of 0.036 ppm was evident at the Edmonton northwest monitoring station. NO is produced primarily from vehicle exhaust and heating fuel combustion.

Total oxides of nitrogen (NO_x), which is the sum of NO_2 and NO, had annual average concentrations that ranged from 0.020 ppm at Fort McMurray to 0.074 ppm at the Calgary industrial monitoring station. Relatively high NO_x concentrations were also observed at the Calgary downtown (0.063 ppm), Edmonton northwest (0.058 ppm) and Edmonton central (0.057 ppm) monitoring stations. The Edmonton central, Edmonton northwest and Calgary industrial stations recorded annual average NO concentrations significantly greater than NO_2 concentrations. At the Calgary residential station, the annual average NO_2 concentration was greater than the NO concentration. The Edmonton east, Calgary downtown, Fort Saskatchewan and Fort McMurray stations recorded annual average NO and NO_2 values that are approximately the same. Monthly frequency distributions of NO_x concentrations are displayed in Figures 4-23 to 4-25.

NO_2 concentrations are generally greater during the fall and winter seasons than during the other seasons of the year. In the fall and winter seasons, persistent temperature inversions will retard the dispersion of pollutants and therefore, lead to higher pollutant concentrations. Heating fuel consumption and automobile emissions also tend to be the highest during the winter season. This seasonal trend was also evident for NO, however, it was not as obvious as it was for NO_2 .

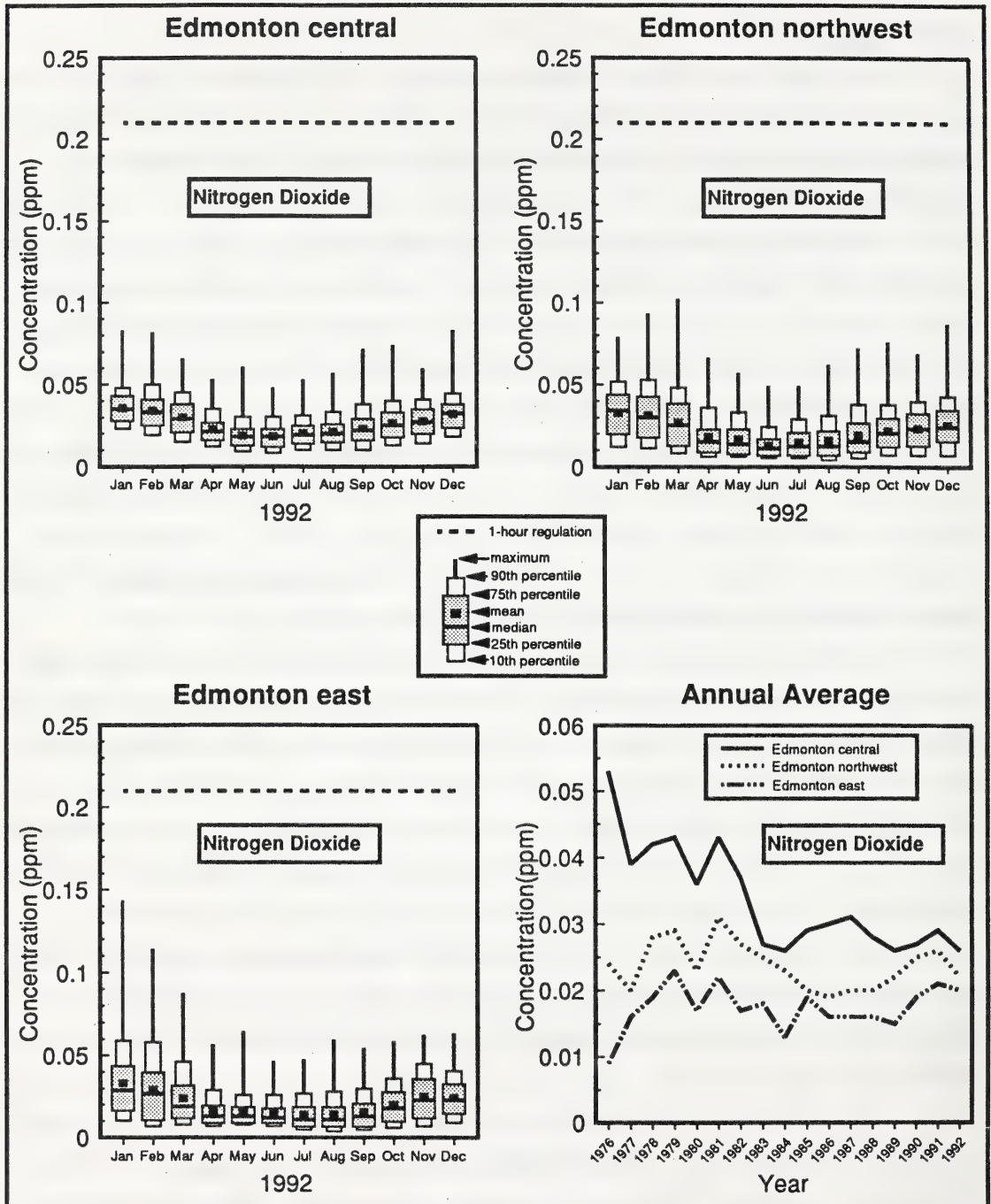


Figure 4-17 Frequency distribution of nitrogen dioxide concentrations at Edmonton.

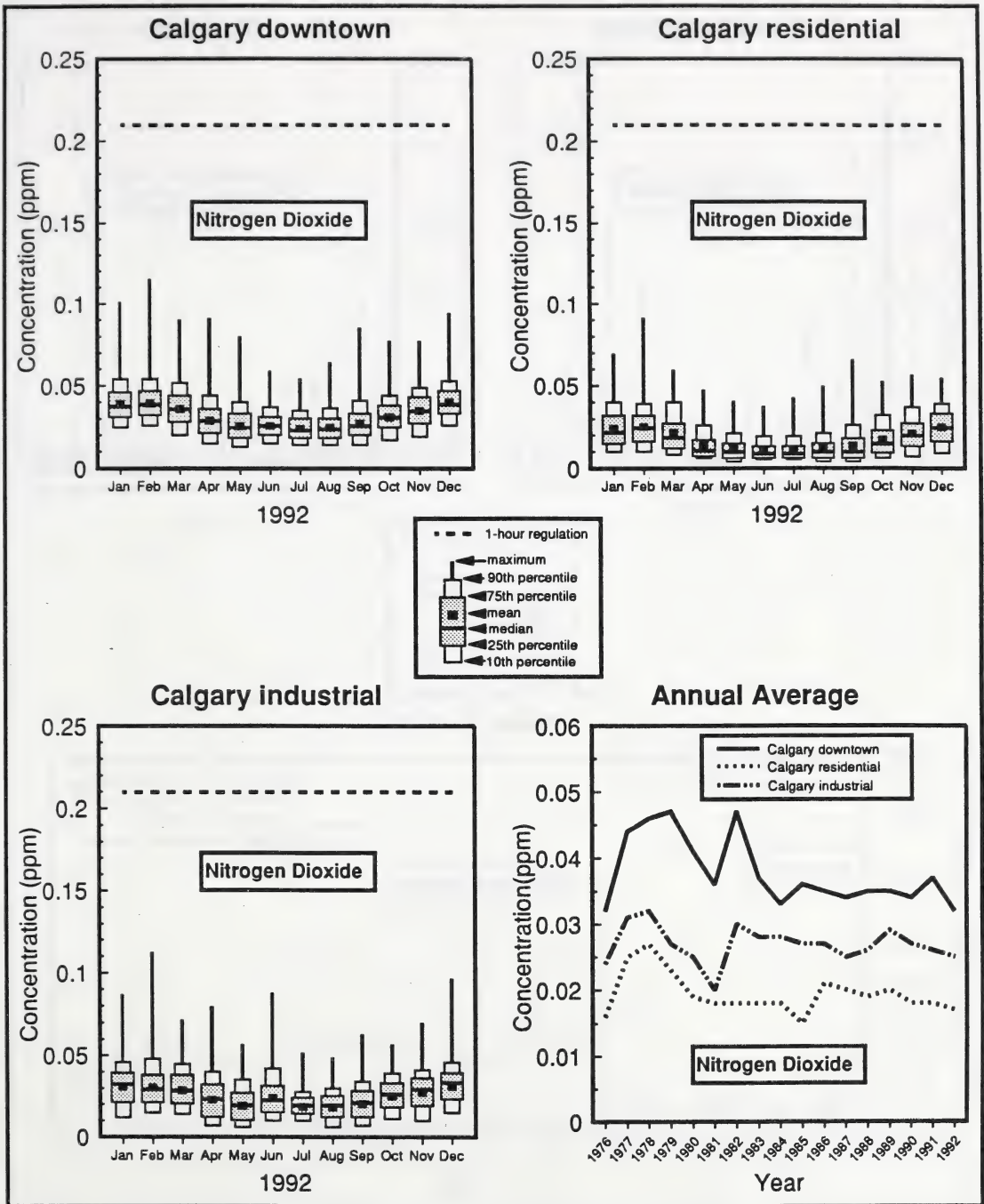


Figure 4-18 Frequency distribution of nitrogen dioxide concentrations at Calgary.

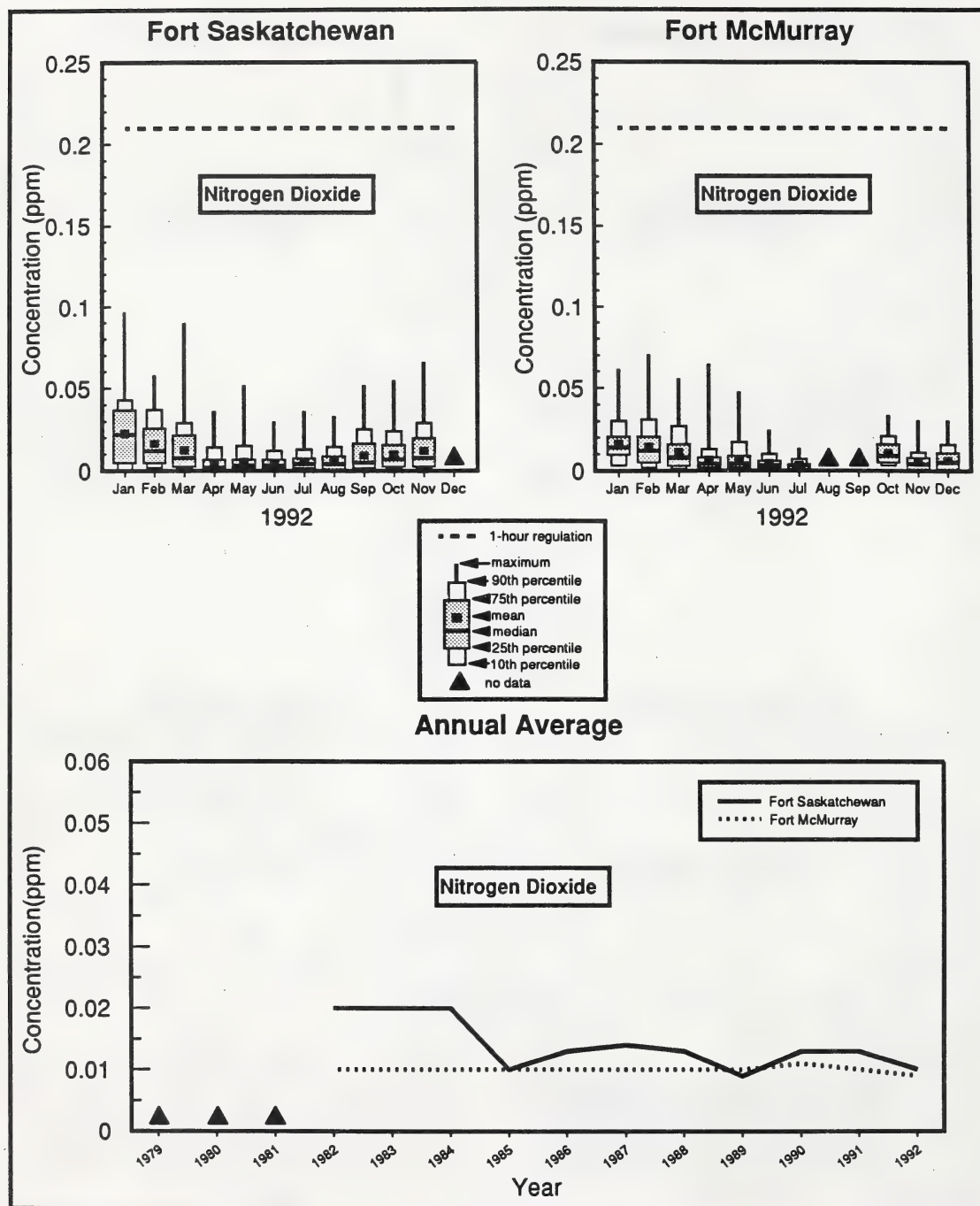


Figure 4-19 Frequency distribution of nitrogen dioxide concentrations at Fort Saskatchewan and Fort McMurray.

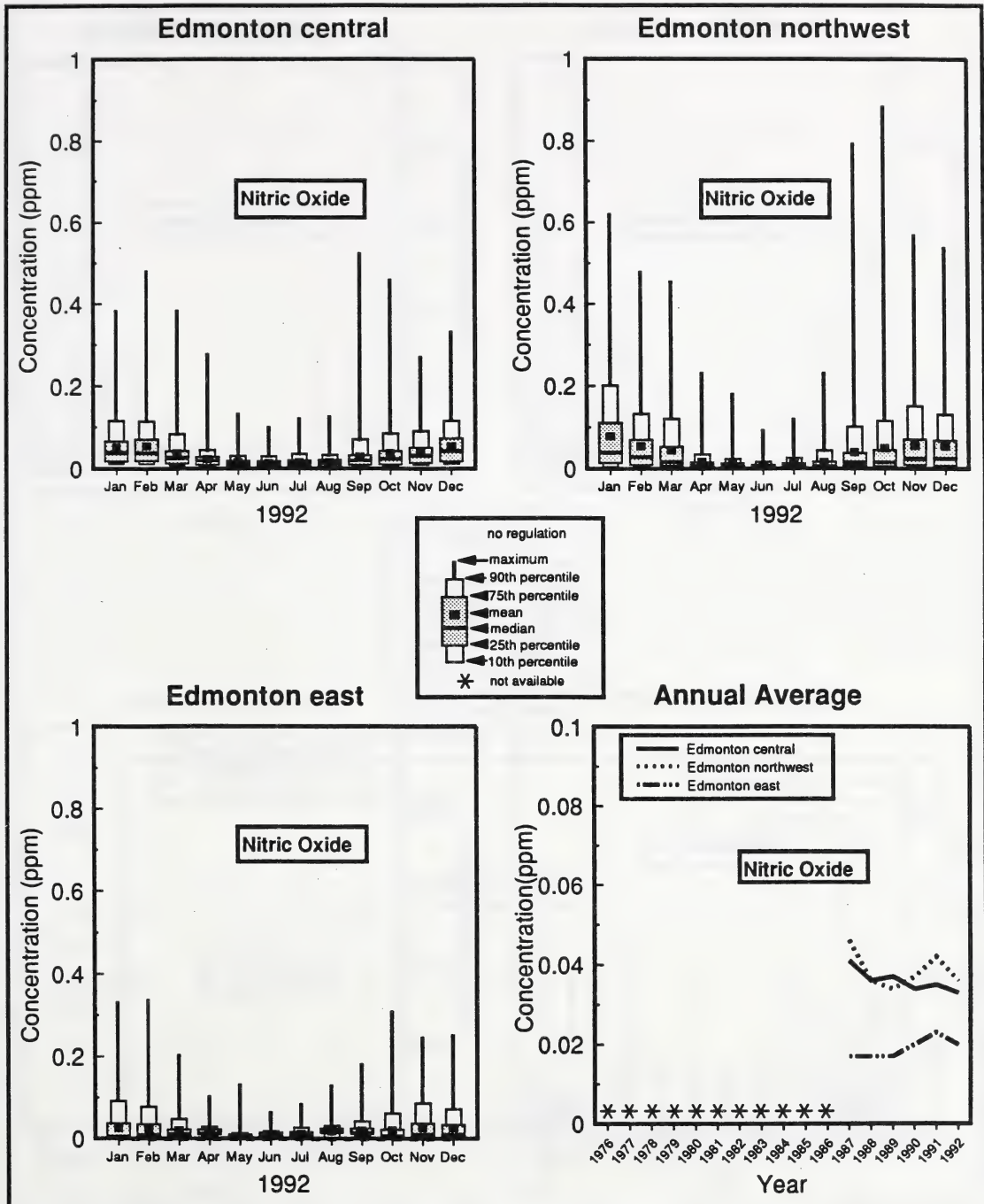


Figure 4-20 Frequency distribution of nitric oxide concentrations at Edmonton.

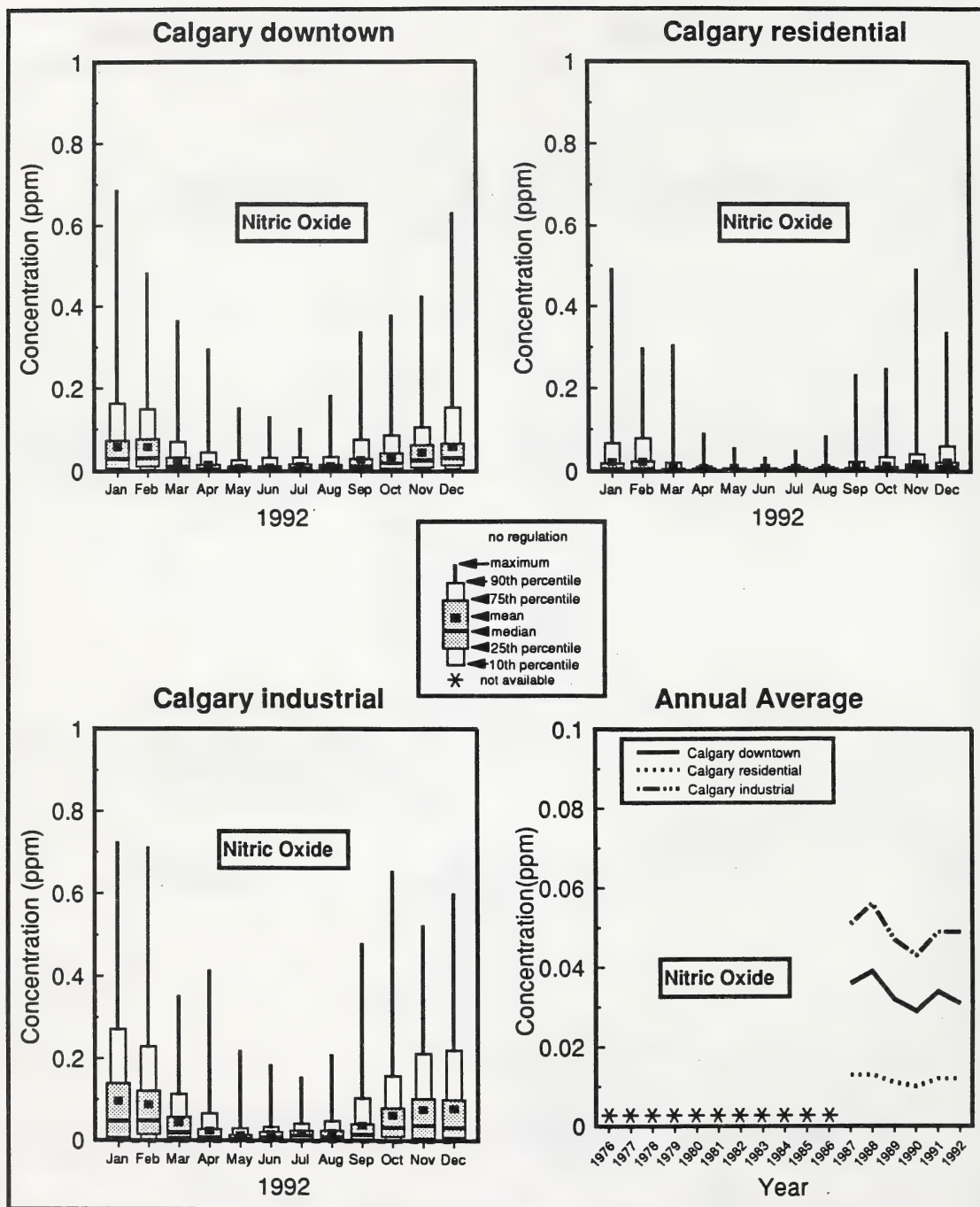


Figure 4-21 Frequency distribution of nitric oxide concentrations at Calgary.

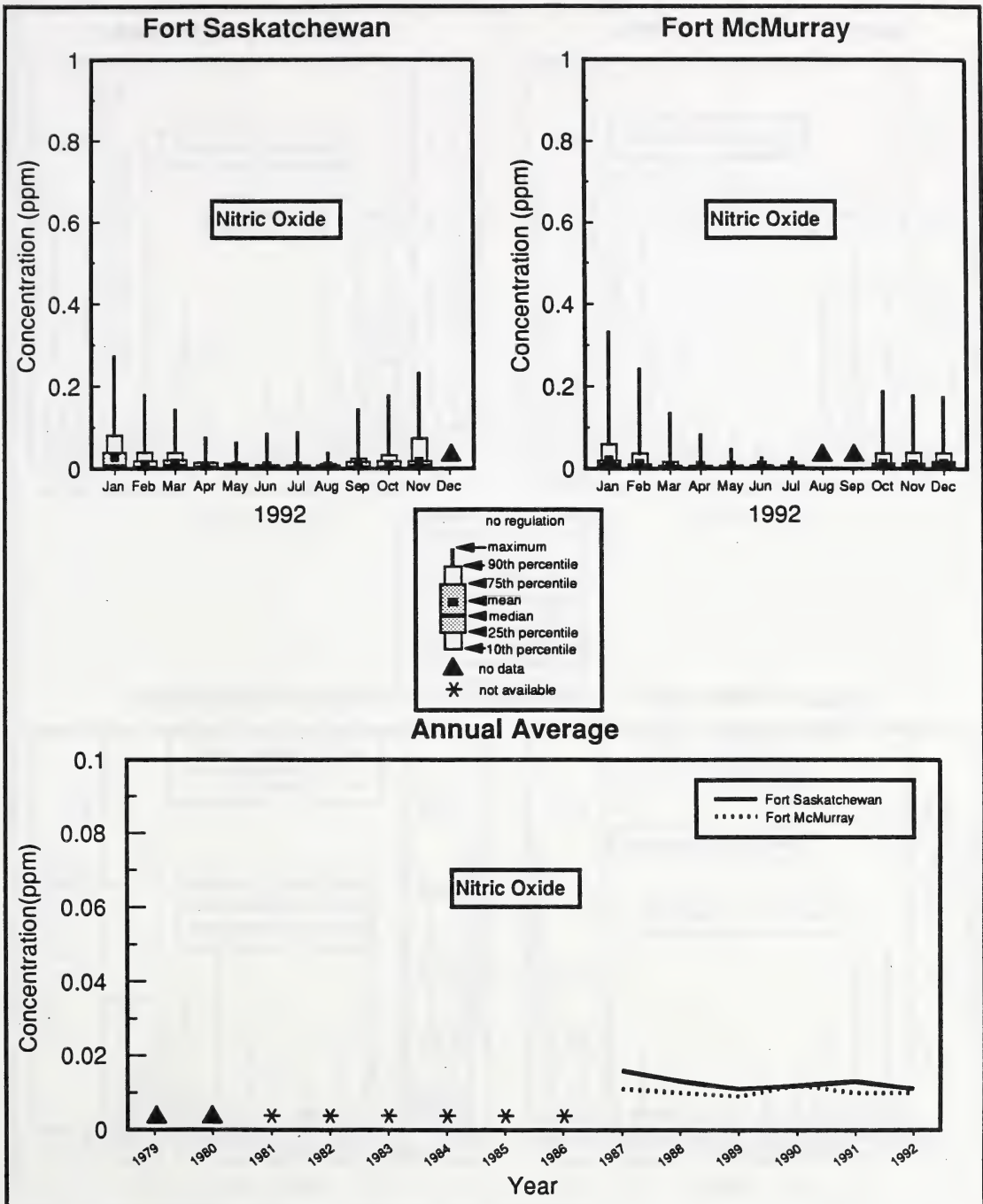


Figure 4-22 Frequency distribution of nitric oxide concentrations at Fort Saskatchewan and Fort McMurray.

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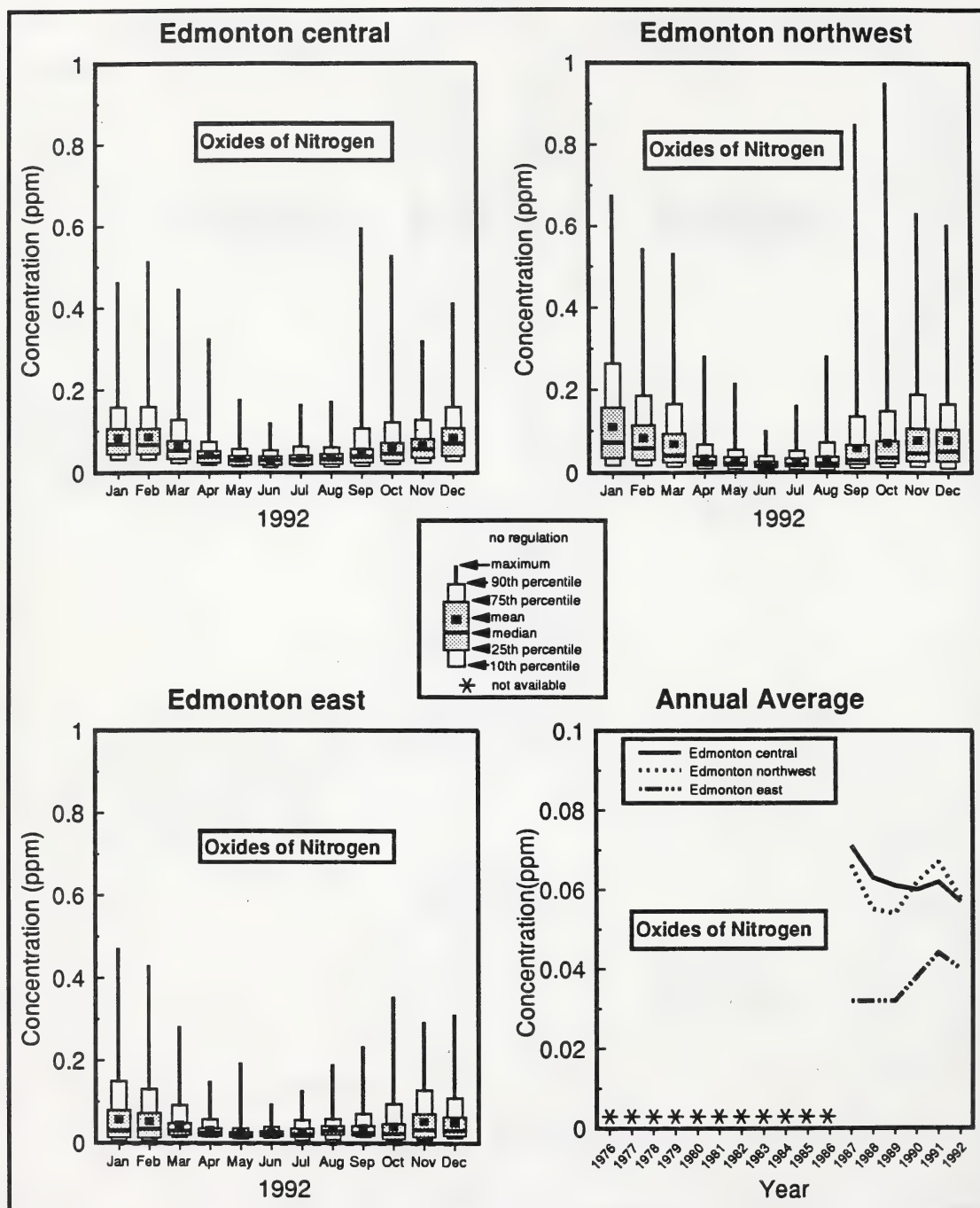


Figure 4-23 Frequency distribution of oxides of nitrogen concentrations at Edmonton.

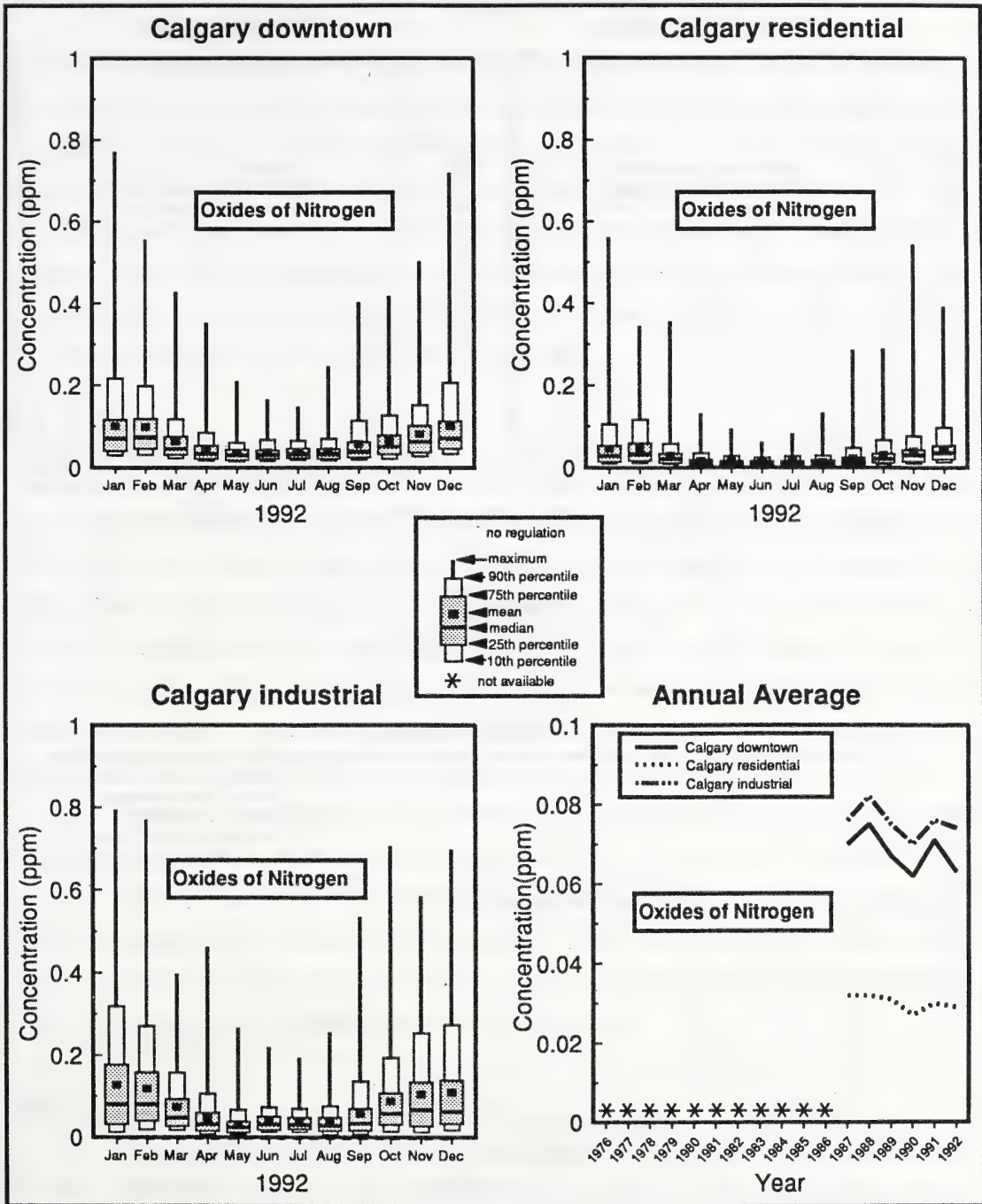


Figure 4-24 Frequency distribution of oxides of nitrogen concentrations at Calgary.

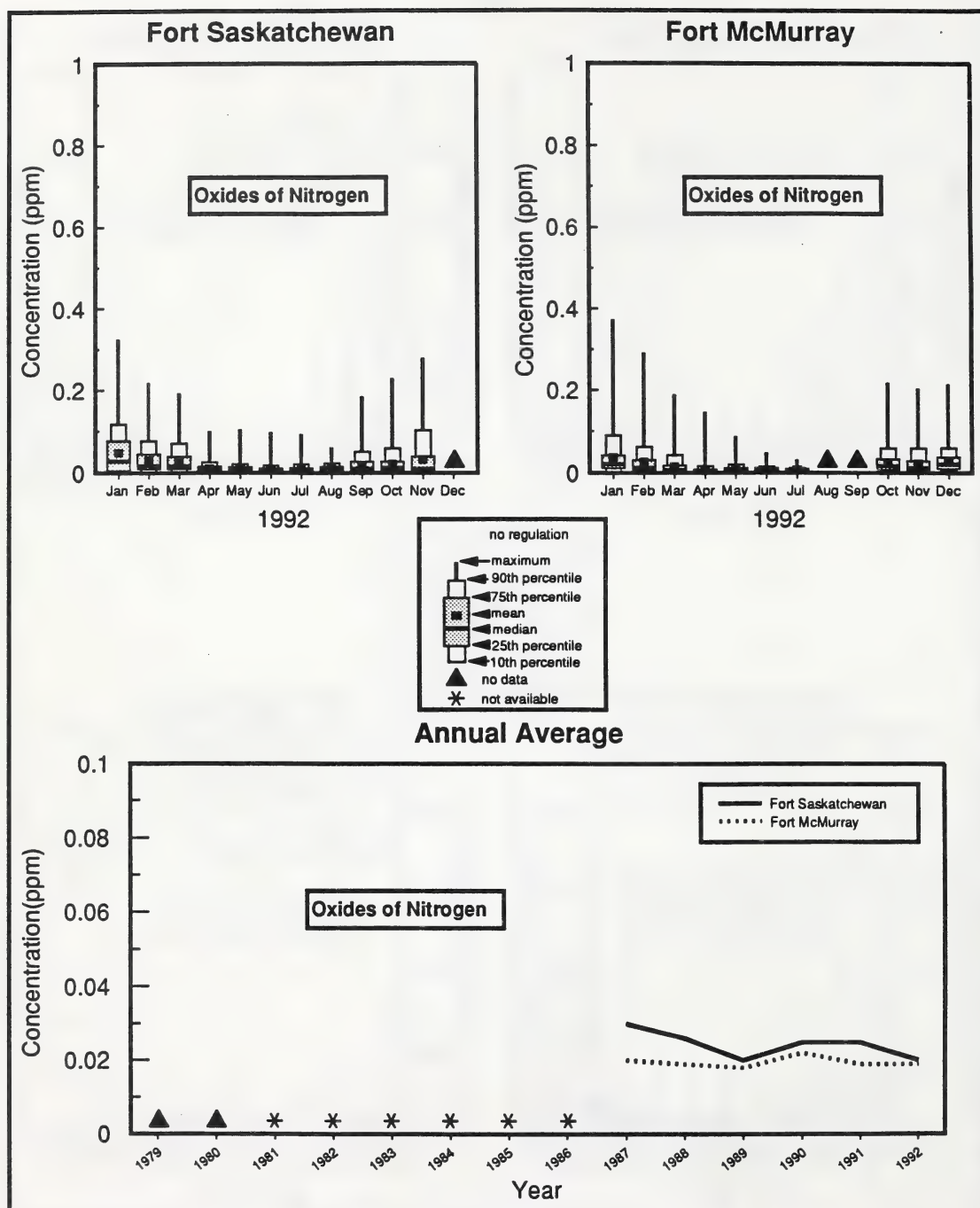


Figure 4-25 Frequency distribution of oxides of nitrogen concentrations at Fort Saskatchewan and Fort McMurray.

A distinct diurnal trend in NO₂ concentrations was evident at the Calgary and Edmonton urban locations. NO₂ values tended to be at a minimum in the early morning hours. An increase in NO₂ concentrations was evident in the morning rush hour and again in the afternoon rush hour. Concentrations begin to drop again at about midnight. This diurnal trend is especially prevalent during the winter months. A diurnal trend is not apparent at more rural locations such as Fort Saskatchewan and Fort McMurray where vehicular emissions are substantially lower. A trend in annual average NO₂ concentrations is not detectable at Calgary, Fort Saskatchewan or Fort McMurray monitoring stations.

4.8.4.1 Edmonton

The 1-hour, 24-hour and annual average regulations for NO₂ were not exceeded at any of the Edmonton monitoring locations. Maximum 1-hour average NO₂ concentrations were 0.082, 0.102 and 0.143 ppm at the central, northwest and east monitoring units, respectively. These values occurred in January at the central and east station and in March at the northwest station. The maximum 24-hour average values were 0.053, 0.055 and 0.065 ppm at the central, northwest and east locations, respectively. These values occurred in December at the central station and in January at the northwest and east stations. Annual average NO₂ concentrations show a significant downward trend at the Edmonton central monitoring station.

Maximum 1-hour average NO concentrations of 0.524 ppm, 0.885 ppm and 0.335 ppm occurred at the central, northwest and east monitoring stations, respectively. These values were recorded in September, October and February, respectively at the central, northwest and east stations. Maximum NO_x concentrations were observed in September, October and January at the central, northwest and east stations, respectively. Peak 1-hour average NO_x concentrations were 0.593, 0.950 ppm and 0.471 ppm at these stations, respectively.

4.8.4.2 Calgary

The annual average regulation for NO₂ was exceeded at the Calgary downtown station in 1992. Regulations for NO₂ were not exceeded at any other Calgary monitoring stations. Maximum 1-hour average concentrations of 0.115 ppm, 0.091 ppm and 0.112 ppm were recorded in February at the downtown, residential and industrial monitoring stations, respectively. A

significant trend in NO_2 concentrations is not evident at any Calgary monitoring stations based on 17 years of data.

Peak 1-hour average NO concentrations of 0.684 ppm, 0.490 ppm and 0.724 ppm occurred at the downtown, residential and industrial monitoring stations, respectively. Maximum NO_x values of 0.769 ppm, 0.557 ppm and 0.794 ppm were observed at the downtown, residential and industrial monitoring locations, respectively. Maximum NO and NO_x concentrations occurred in January at all monitoring stations.

4.8.4.3 Fort Saskatchewan

Maximum 1-hour average NO_2 , NO, and NO_x concentrations were 0.096 ppm, 0.274 ppm, and 0.322 ppm, respectively at the Fort Saskatchewan monitoring station. The maximum values were recorded in January. Regulations for 1-hour, 24-hour and annual average NO_2 concentrations were not exceeded in Fort Saskatchewan. Annual average concentrations do not show a trend at the Fort Saskatchewan station.

4.8.4.4 Fort McMurray

The ambient air quality regulations for NO_2 were not exceeded at the Fort McMurray monitoring unit in 1992. Peak 1-hour average values were 0.070 ppm for NO_2 , 0.334 ppm for NO and 0.372 ppm for NO_x . Peak values for NO and NO_x were observed in January while the maximum NO_2 concentration was recorded in February. A significant trend in NO_2 values is not apparent in Fort McMurray.

4.9 OZONE (O_3)

4.9.1 Characteristics

At normal ambient concentrations, O_3 is a colourless, odourless gas. However, O_3 does have a characteristic sharp odour when at very high concentrations (i.e., photocopier machines, electrical discharges associated with arcing electric motors and lightning storms). Unlike many other pollutants, O_3 is not emitted into the atmosphere directly by man's activities, but is produced through the inter-reaction of other atmospheric constituents. In the upper atmosphere, O_3 is a naturally-occurring compound; in the lower atmosphere, O_3 is the primary end-product

of photochemical reactions involving oxides of nitrogen and reactive hydrocarbons (vapours from automobile exhaust, paints, inks, solvents and gasoline) with ultra-violet light from the sun. O_3 is formed through the dissociation of NO_2 by sunlight to yield an oxygen atom, which may react with molecular oxygen to form an O_3 molecule.

The highest levels of O_3 generally occur during the spring and summer months. In the summer, the hours of sunlight are longer and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Occasionally, meteorological conditions can result in stratospheric O_3 being brought down to ground level, a phenomenon known as tropopause folding.

O_3 concentrations tend to be lower in urban locations than rural locations. Cities act as sinks, destroying O_3 that is formed in or near the city. In urban areas, NO emitted from motor vehicles reacts with O_3 to produce NO_2 and molecular oxygen. By contrast, in rural areas with less vehicles, naturally generated O_3 (produced by the reaction of sunlight with NO_x and natural hydrocarbons or from tropopause folding) is less prone to destruction by NO.

4.9.2 Method of Monitoring

O_3 is continuously monitored by either the chemiluminescence or ultra-violet photometry process. The chemiluminescence process involves the reacting of an air sample with ethylene. The reaction of ethylene and O_3 produces light. The intensity of the light produced is proportional to the O_3 concentration. The ultra-violet photometry process uses a mercury vapour lamp as a source of ultra-violet radiation. This method determines the O_3 concentration by the amount of ultra-violet radiation that is absorbed by the O_3 in the sample.

4.9.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of O_3 are based on the prevention of human health effects. Alberta has high natural levels of O_3 and frequently, especially in rural locations, exceeds the 24-hour regulation (Angle and Sandhu 1986). The ambient air quality regulations for O_3 in Alberta are:

- ▲ 0.082 ppm as a 1-hour average concentration; and
- ▲ 0.025 ppm as a 24-hour average concentration.

4.9.4 Results

Ambient concentrations of O_3 were monitored at all three Edmonton and Calgary air monitoring stations as well as Fort Saskatchewan and Fort McMurray. A frequency distribution of monthly O_3 concentrations and annual average O_3 concentrations for these locations is presented in Figures 4-26 to 4-28.

Annual average O_3 concentrations ranged from 0.013 ppm at the Calgary downtown monitoring station to 0.021 ppm at the Calgary residential and Fort McMurray monitoring sites. Relatively high annual average concentrations also occurred at the Edmonton industrial and Fort Saskatchewan monitoring stations. Lower annual average O_3 concentrations were generally recorded at monitoring stations that are located in areas with high traffic density. This is because higher concentrations of NO from motor vehicle emissions will act as a mechanism for O_3 destruction.

Average O_3 concentrations reached a maximum during the spring and summer months at all monitoring stations. During the spring and summer months, O_3 production reaches a maximum due to a peak in incoming solar radiation combined with stagnant meteorological conditions which may cause reactive pollutants to remain in the region for a prolonged period of time. Transport of rural background O_3 to urban locations is also a common cause of high O_3 in Edmonton and Calgary. High daily average O_3 concentrations in the spring may be due to transport of ozone from the upper atmosphere.

A noticeable trend towards higher O_3 concentrations in the afternoon was evident at all monitoring locations. O_3 concentrations tended to increase to a maximum in late afternoon and then drop off to a minimum in the early morning hours. The afternoon peak in O_3 is due to a corresponding peak in incoming solar radiation.

4.8.4.1 Edmonton

The 1-hour average regulation for O_3 was not exceeded at any Edmonton stations in 1992. Peak 1-hour average O_3 concentrations of 0.070, 0.075 and 0.082 ppm were observed at the central, northwest and east monitoring stations, respectively. These maximum values were recorded in August at the central and northwest stations and June at the east station.

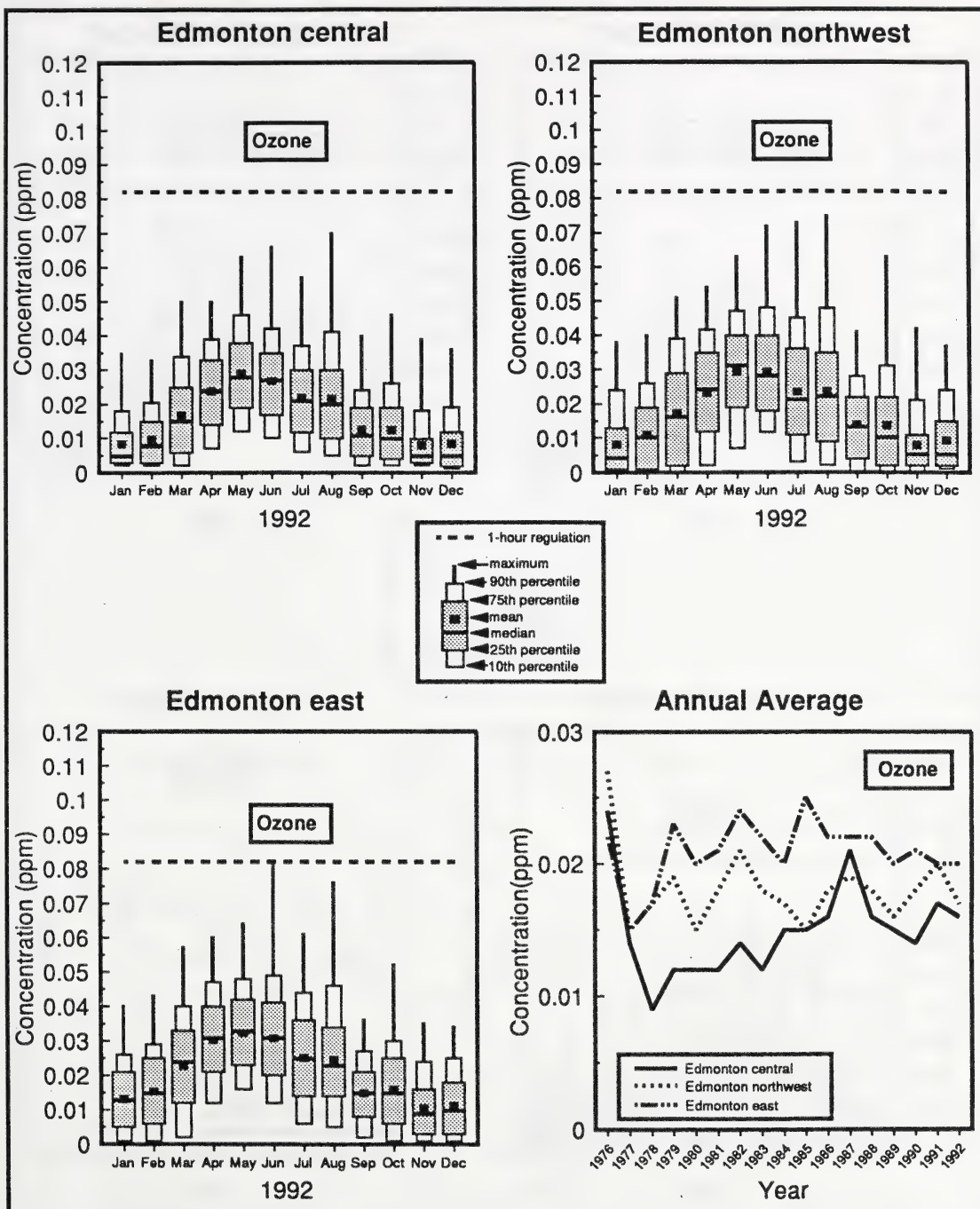


Figure 4-26 Frequency distribution of ozone concentrations at Edmonton.

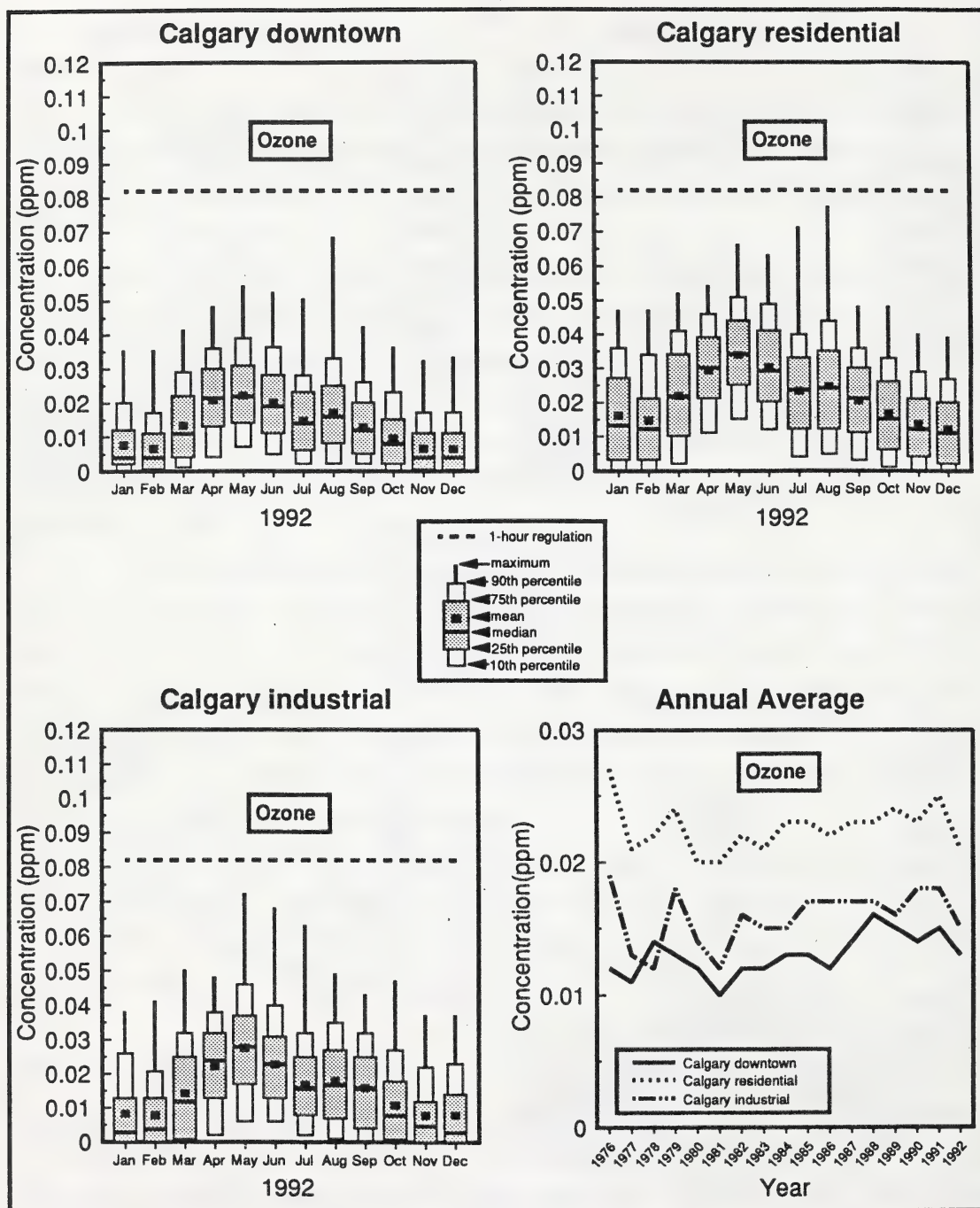


Figure 4-27 Frequency distribution of ozone concentrations at Calgary.

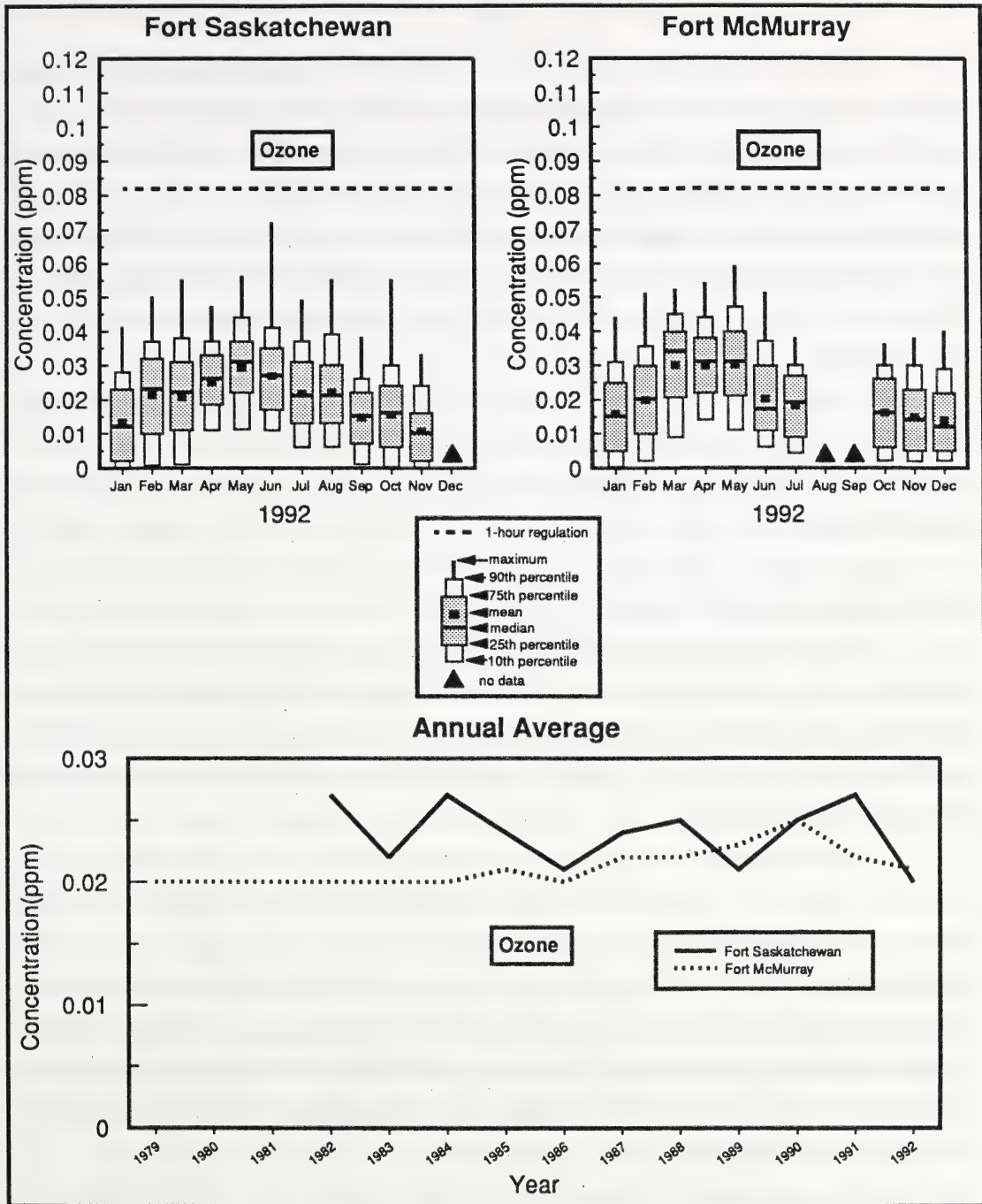


Figure 4-28 Frequency distribution of ozone concentrations at Fort Saskatchewan and Fort McMurray.

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The 24-hour average regulation for O_3 was exceeded at all Edmonton monitoring locations. The frequency of exceedances ranged from 68 days at the central station to 116 days at the east station. The months of April to June generally recorded the highest frequency of exceedances of this regulation. Exceedances of the 24-hour regulation were also occasionally recorded during the summer months at the Edmonton monitoring stations. The overall maximum 24-hour average O_3 concentration was ppm which occurred at the northwest monitoring location. Background O_3 transported from rural locations is largely responsible for exceedances of the 24-hour regulation.

A slight increase in annual average O_3 values is detectable at the central air quality station. This trend is may be related to lower NO_x values in downtown Edmonton (i.e. background O_3 is transported into the city and is destroyed through a reaction with NO emitted by automobiles).

4.9.4.2 Calgary

The 1-hour average regulation for O_3 was not exceeded at any Calgary monitoring locations in 1992. Peak 1-hour average O_3 concentrations of 0.068, 0.077 and 0.072 ppm were observed at the downtown, residential and industrial monitoring locations, respectively. Maximum 1-hour average values occurred in August at the downtown and residential stations and May at the industrial station.

The frequency of exceedances of the 24-hour regulation for O_3 ranged from 27 at the downtown station to 44 at the industrial station to 120 at the residential station. The greatest frequency of exceedances of this regulation occurred in April and May at the downtown and industrial stations and April, May and June at the residential station. These exceedances are caused by the import of background, naturally generated O_3 into the city. A slight upward trend in annual average O_3 concentrations is indicated at the Calgary downtown monitoring station. This upward trend is likely due to less background O_3 being destroyed through the reaction with NO emitted by automobiles.

4.9.4.3 Fort Saskatchewan

The 1-hour average regulation for O_3 was not exceeded in Fort Saskatchewan in 1992. The overall maximum O_3 concentration was 0.072 ppm which was observed in June. The 24-hour regulation was exceeded 89 times at this location in 1992. These exceedances were most frequent from February to June. Again, the source of high 24-hour ozone concentrations was naturally generated O_3 . No significant trend in annual average O_3 concentrations is noted at the Fort Saskatchewan monitoring unit.

4.9.4.4 Fort McMurray

No exceedances of the 1-hour regulation for O_3 were recorded at the Fort McMurray monitoring station in 1992. A maximum 1-hour average of 0.059 ppm was recorded in May at the Fort McMurray station. As with other monitoring locations, the 24-hour regulation for O_3 was exceeded frequently (86 times) at the Fort McMurray station. The 24-hour regulation was exceeded most frequently from March to May. There is a substantial decrease in the frequency of exceedances of the 24-hour regulation in the summer, autumn and winter months. A peak 24-hour average concentration of 0.043 ppm occurred in March. Background, naturally generated O_3 is the major O_3 source in Fort McMurray. A very slight trend towards higher annual average O_3 concentrations is evident at the Fort McMurray monitoring station based on 14 years of data. However, lower annual average values have been recorded in the past two years (1991 and 1992).

4.10 SULPHUR DIOXIDE (SO_2)

4.10.1 Characteristics

SO_2 is a heavy, colourless gas with a pungent odour and is designated as a major atmospheric pollutant on a global basis. Processes such as combustion of fossil fuels, smelting and roasting of sulphur-containing ores, kraft and sulphite wood pulping, and sour gas processing produce most of the man-made SO_2 in the atmosphere.

In Alberta, during 1988 an estimated 626 kilotonnes of SO_2 were emitted into the atmosphere from man-made sources. About 38% of the SO_2 emissions was contributed by sulphur extraction gas plants; oil sands plants and coal-fired power plants contributed about 29% and 16%, respectively. The remaining 15% was emitted from sources such as gas plant flares,

oil refineries, pulp and paper mills and fertilizer plants (Energy Resources Conservation Board, Alberta Energy and Alberta Environment 1990).

4.10.2 Method of Monitoring

SO₂ is monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any SO₂ in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the SO₂ concentration.

4.10.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of SO₂ are based on preventing damage to vegetation. At these levels, no known health effects are detectable. In regulating SO₂, Alberta has adopted Environment Canada's most rigorous ambient regulation:

- ▲ 0.17 ppm as a 1-hour average concentration;
- ▲ 0.06 ppm as a 24-hour average concentration; and
- ▲ 0.01 ppm as an annual arithmetic concentration.

4.10.4 Results

SO₂ was monitored on a continuous basis at Edmonton east, Calgary industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring stations. Figures 4-29 to 4-31 show monthly frequency distributions and annual averages of SO₂ at these monitoring locations.

Annual average SO₂ concentrations ranged from 0.002 ppm at the Edmonton east and Fort Saskatchewan stations to 0.003 ppm at all other stations. These values are substantially lower than the annual average regulation of 0.010 ppm for SO₂. At the Edmonton, Calgary and Fort Saskatchewan stations, SO₂ concentrations tend to be higher in the late fall, winter and early spring months. At the Fort McMurray and Fort MacKay stations, maximum SO₂ concentrations are usually observed in the late winter and spring seasons. A well-defined diurnal trend in SO₂ is not evident. Annual average SO₂ concentrations are not high enough to resolve a significant trend.

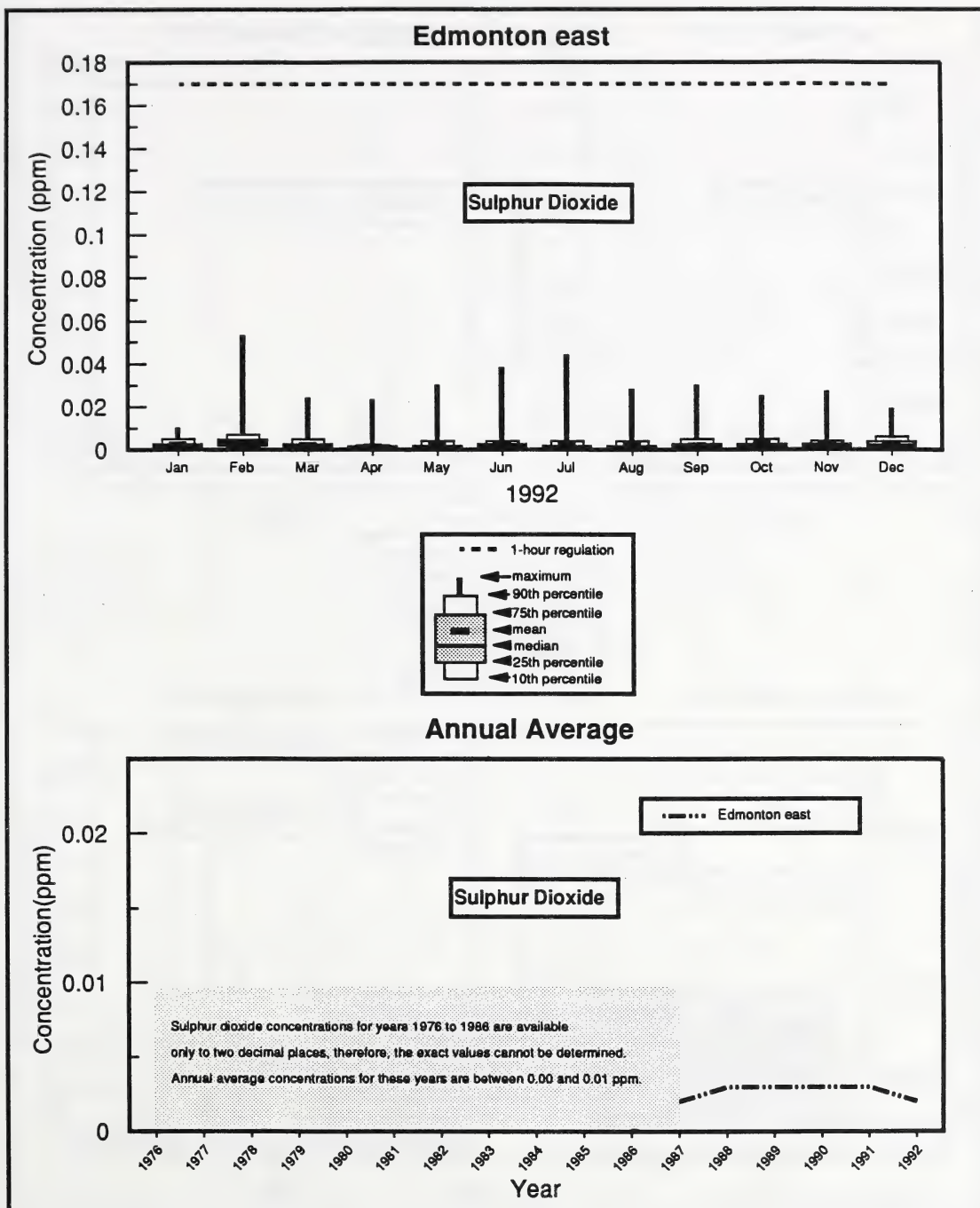


Figure 4-29 Frequency distribution of sulphur dioxide concentrations at Edmonton.

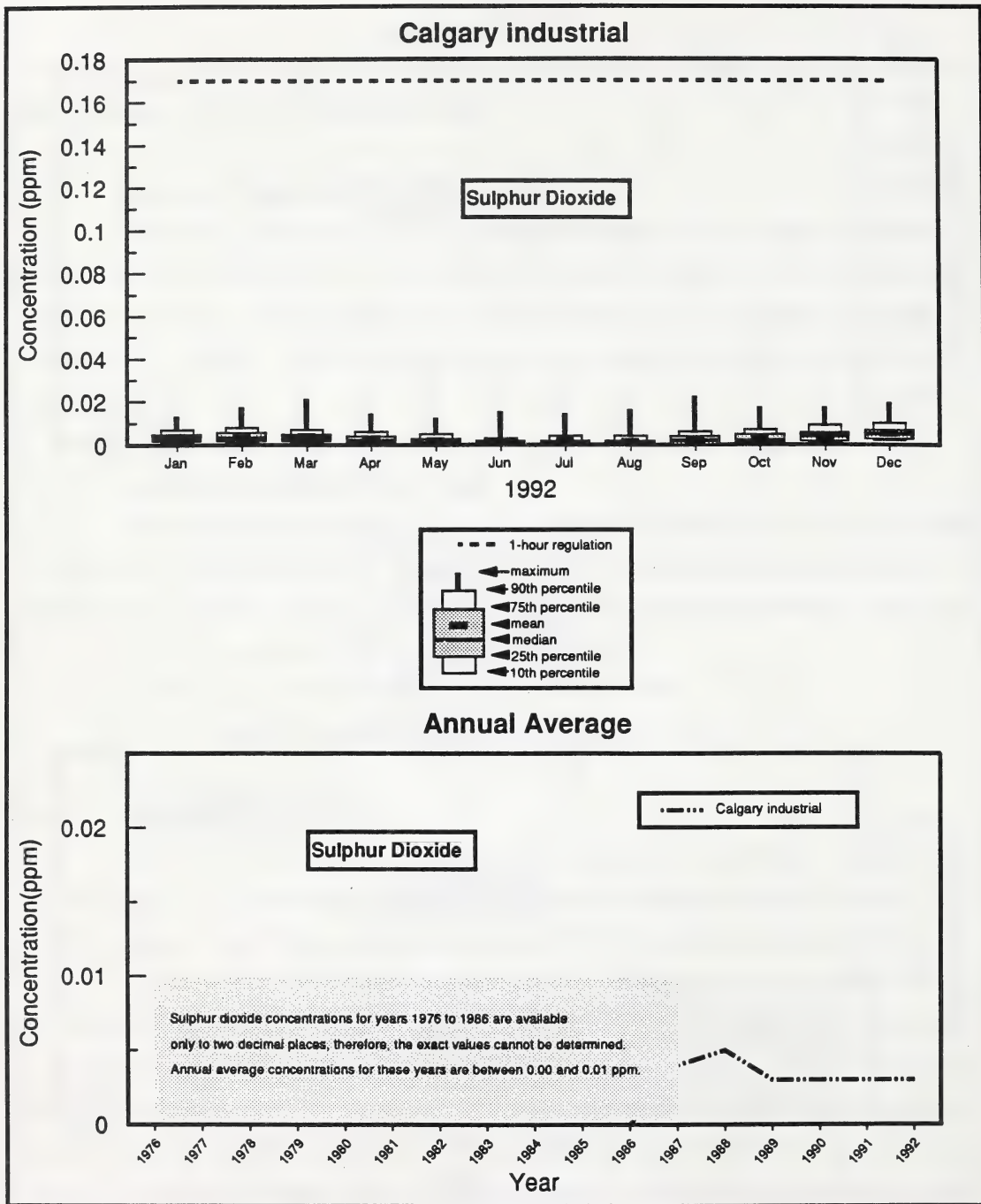


Figure 4-30 Frequency distribution of sulphur dioxide concentrations at Calgary.

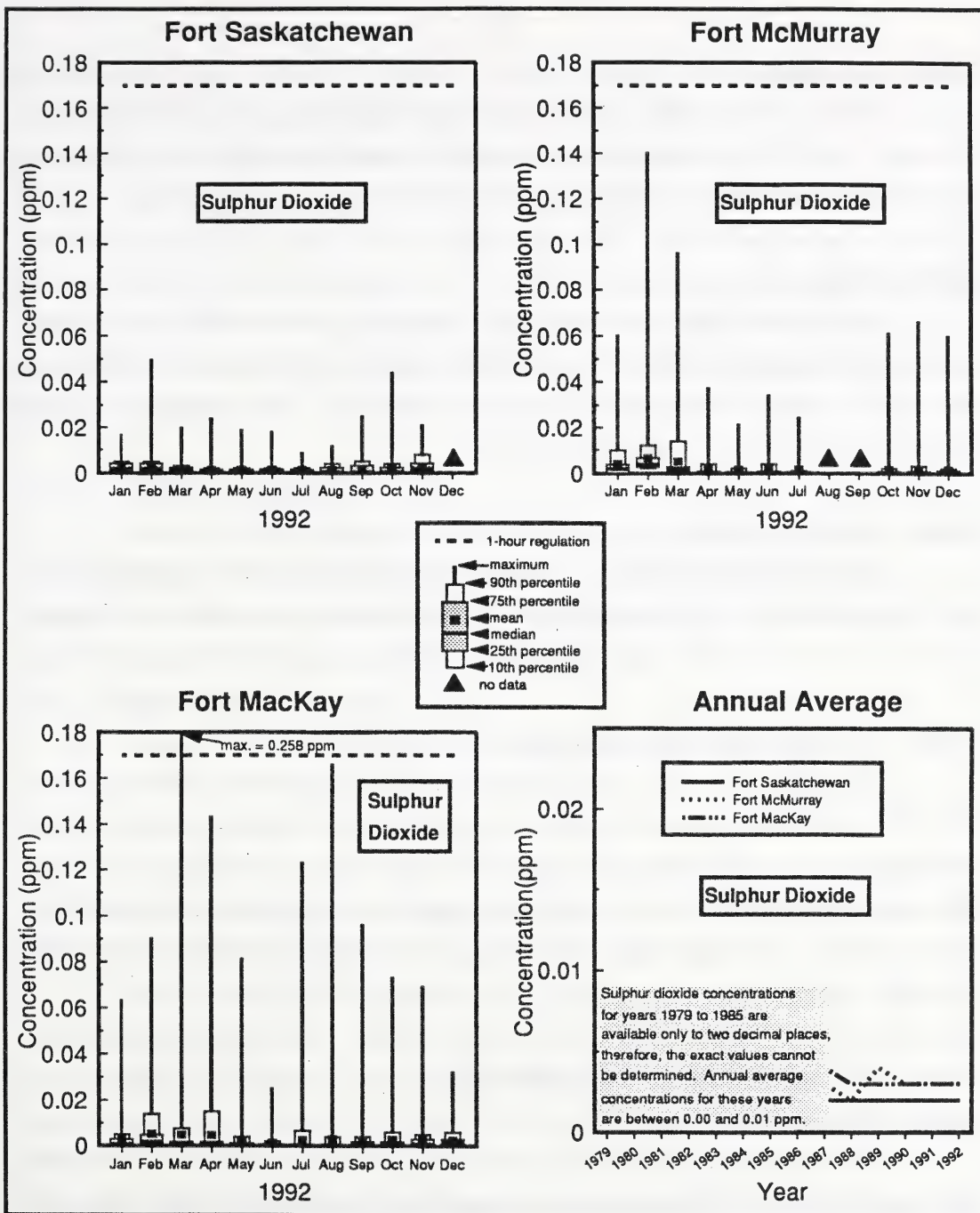


Figure 4-31 Frequency distribution of sulphur dioxide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

4.10.4.1 Edmonton

The regulations for SO₂ were not exceeded at the Edmonton east monitoring location. The peak 1- and 24-hour average SO₂ concentrations observed were 0.053 and 0.011 ppm, respectively. These peak values were recorded in February.

4.10.4.2 Calgary

The maximum observed 1- and 24-hour average SO₂ concentrations at the Calgary industrial monitoring station were 0.022 and 0.010 ppm, respectively. Maximum 1- and 24-hour values were recorded in September and December, respectively. These maximum values are substantially lower than the regulations for SO₂.

4.10.4.3 Fort Saskatchewan

Regulations for SO₂ were not exceeded at the Fort Saskatchewan monitoring unit in 1992. The maximum 1- and 24-hour average SO₂ concentrations were 0.050 and 0.010 ppm, respectively. These maximum values were recorded in February and November, respectively.

4.10.4.4 Fort McMurray and Fort MacKay

The regulations for SO₂ were not exceeded at the Fort McMurray monitoring unit in 1992. One exceedance of 1-hour regulation was recorded at Fort MacKay. Maximum 1-hour concentrations at Fort McMurray and Fort MacKay were 0.140 and 0.258 ppm, respectively. These maximum values were recorded in February and March, respectively for Fort McMurray and Fort MacKay. The wind direction during the exceedance episode at Fort MacKay was from the south.

4.11 TOTAL HYDROCARBONS (THC)

4.11.1 Characteristics

The term "total hydrocarbons" refers to the combined concentration of two broad categories of organic compounds: reactive and non-reactive hydrocarbons. The non-reactive component is primarily methane, a colourless, odourless gas that is naturally present in the atmosphere at concentrations of about 1.5 ppm. The reactive component is essentially organic

compounds other than methane that are usually present in much lower concentrations (Volatile Organic Compounds). Reactive hydrocarbons are especially important because they will react with oxides of nitrogen in the presence of sunlight to form ozone.

Natural sources of hydrocarbons include trees and other vegetation, and the decay of animal and plant material. The primary man-made sources of hydrocarbons are motor vehicles, gasoline marketing tanks and storage tanks. Smaller amounts of hydrocarbons are emitted by sources such as the petroleum and chemical industries, drycleaning, fireplaces, natural gas combustion and aircraft traffic. Motor vehicle emissions of hydrocarbons are the result of incomplete combustion.

4.11.2 Method of Monitoring

Hydrocarbons are monitored continuously by a hydrogen flame ionization detector. When burned, carbon-hydrogen bonds break creating ions that conduct an electric current. This current is then measured by an electrometer to give a signal proportional to the number of ions.

4.11.3 Regulations and Guidelines

Alberta currently has no ambient air quality regulations for hydrocarbons.

4.11.4 Results

Hydrocarbons were monitored at all Alberta Environmental Protection continuous air quality stations in 1992. Frequency distributions of these values are illustrated in Figures 4-32 to 4-34. These figures also show annual average THC concentrations.

Annual average THC concentrations ranged from 1.8 ppm at Fort MacKay to 2.5 ppm at the Edmonton central station. The lowest annual average concentrations were recorded at the Fort McMurray, Fort MacKay and Calgary residential monitoring units while the highest concentrations were measured at the stations located close to major traffic arteries or industrial sources.

A distinct seasonal trend in hydrocarbon concentrations is not evident based on data collected in 1992. At urban locations, such as Edmonton and Calgary, the predominant source

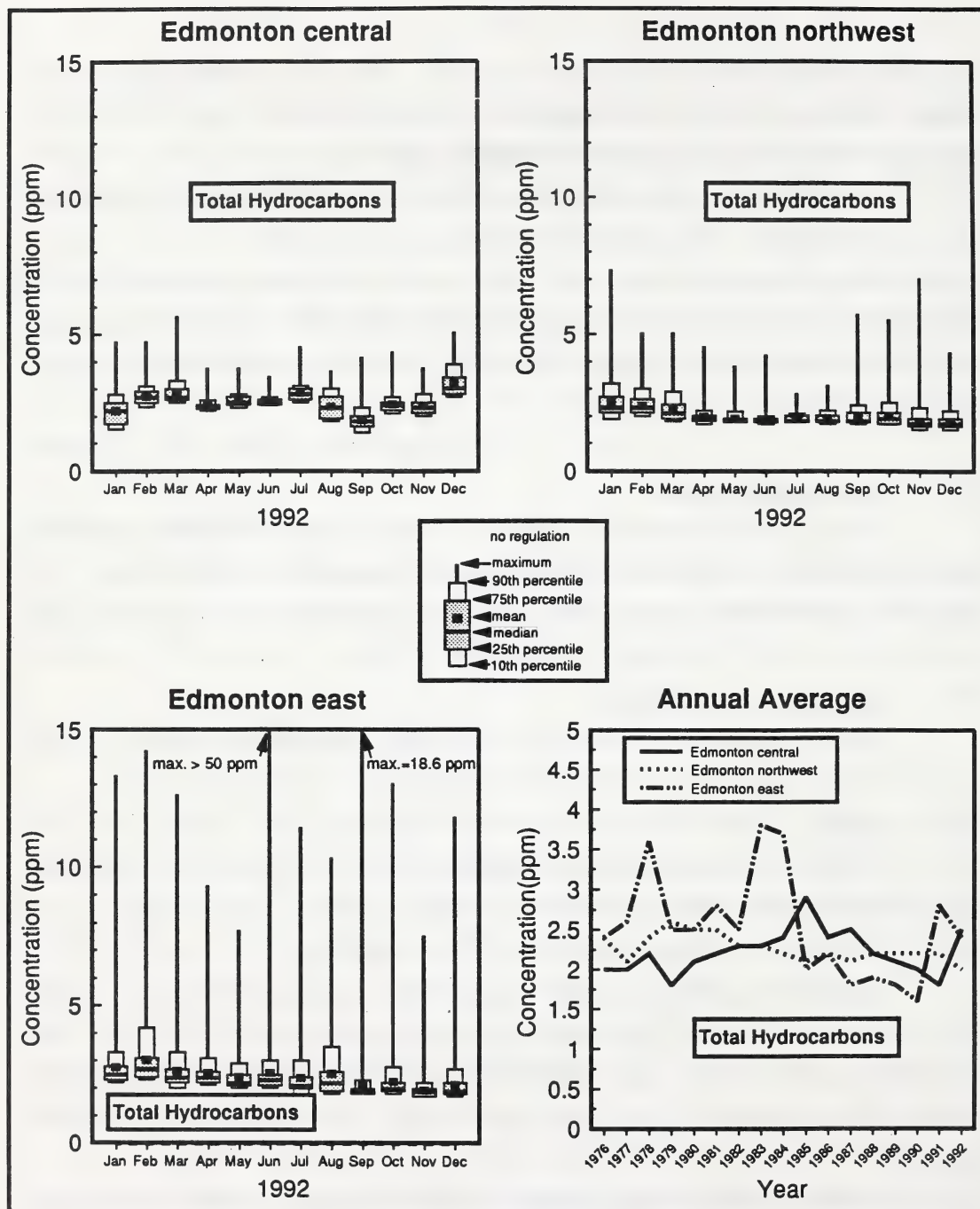


Figure 4-32 Frequency distribution of total hydrocarbon concentrations at Edmonton.

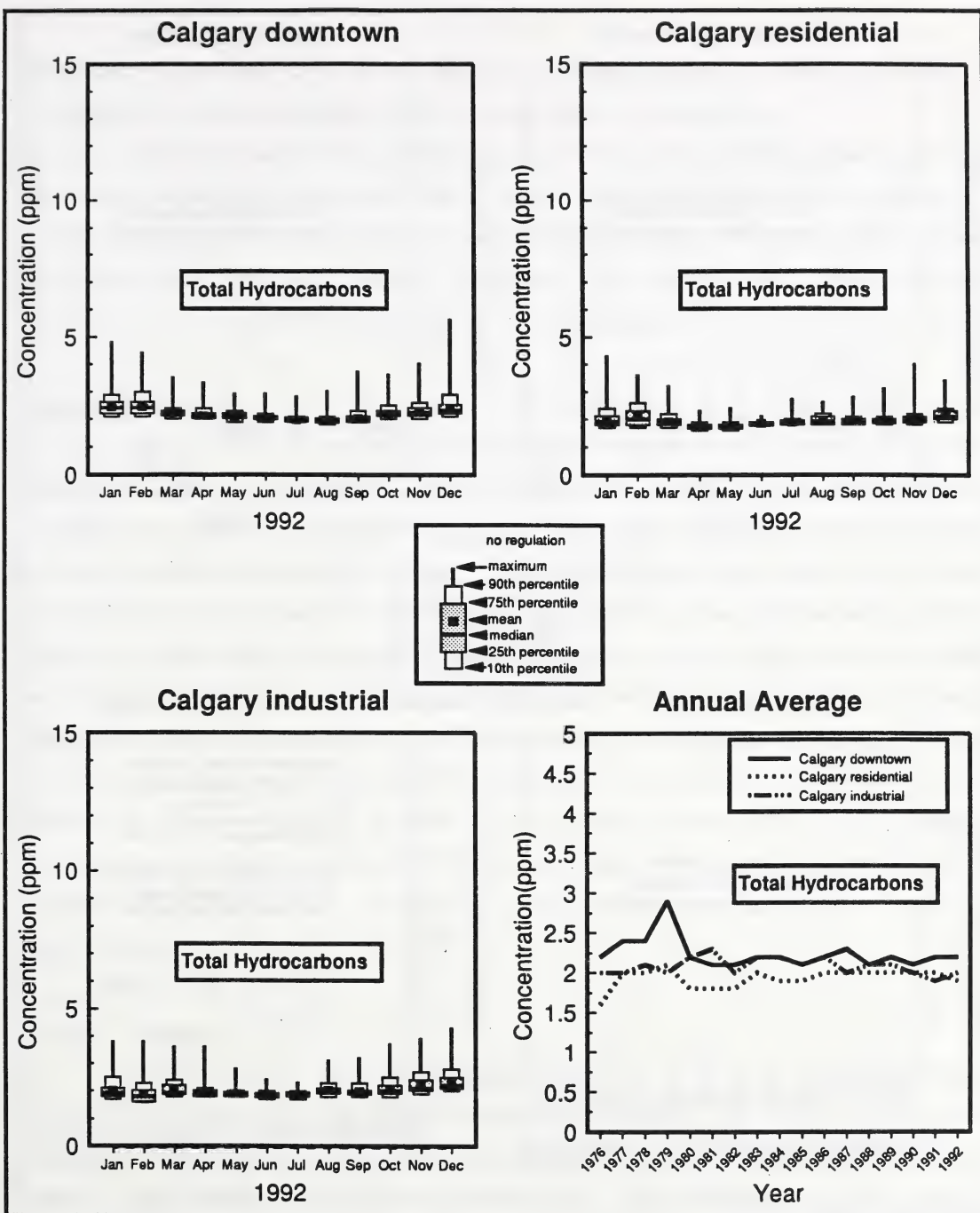


Figure 4-33 Frequency distribution of total hydrocarbon concentrations at Calgary.

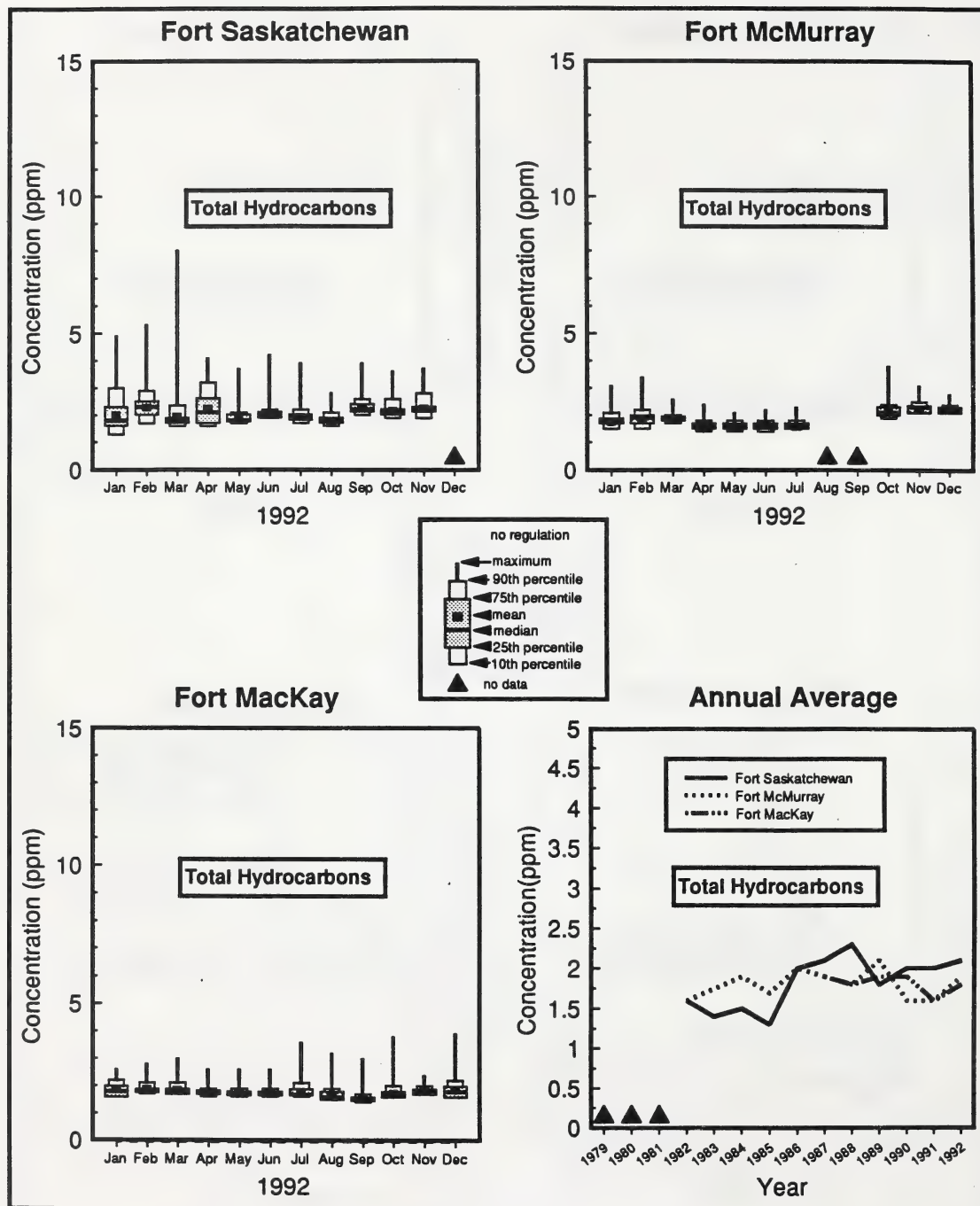


Figure 4-34 Frequency distribution of total hydrocarbon concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

Alberta

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Environmental Assessment Division
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of reactive hydrocarbons was automobile emissions. Industrial sources contribute to the majority of hydrocarbon readings at the Edmonton east and Calgary industrial area.

Significant diurnal trends of THC were noted at air quality monitoring stations that are located close to major traffic arteries. Diurnal trends were especially evident during the winter months at the Edmonton central, Edmonton northwest, Calgary downtown, Calgary industrial and Fort Saskatchewan monitoring stations. Maximum THC concentrations at these locations generally occurred during the morning and afternoon rush hours.

4.11.4.1 Edmonton

Maximum 1-hour average THC concentrations ranged from 5.6 ppm at the central station to 7.3 ppm at the northwest station to greater than 50.0 ppm at the east monitoring location. These peak values were recorded in March, January and June at the central, northwest and east monitoring stations, respectively. THC concentrations greater than 10 ppm were observed in all months except for April, May and November at the east monitoring station. Maximum concentrations at the central and northwest stations were generally observed in the fall and winter. High THC concentrations observed in the industrial region of east Edmonton were likely due to fugitive emissions originating from petrochemical storage tanks and transportation vehicles. Annual average THC values at the Edmonton east station are 15% lower than that recorded in 1991. Based on 17 years of data, a slight upward trend in hydrocarbon concentrations is noticeable at the central monitoring station while a small downward trend is evident at the northwest station. These trends can be attributed to emissions from vehicles at both locations.

4.11.4.2 Calgary

Maximum 1-hour THC concentrations ranged from 4.3 ppm at the residential and industrial monitoring units to 5.6 ppm at the downtown monitoring unit. Peak values occurred in January at the residential monitoring station and in December at the downtown and industrial stations. Annual average THC concentrations do not show a trend at Calgary monitoring stations.

4.11.4.3 Fort Saskatchewan

The maximum 1-hour average THC concentrations observed at the Fort Saskatchewan monitoring unit was 8.0 ppm, recorded in March. The sources of hydrocarbons in the Fort Saskatchewan region are vehicle emissions and emissions from local industrial facilities. Based on 11 years of data, an increase in THC values is evident at the Fort Saskatchewan station.

4.11.4.4 Fort McMurray and Fort MacKay

Maximum 1-hour average THC concentrations of 3.8 and 3.9 ppm were measured, respectively, at Fort McMurray and Fort MacKay. These values were recorded in October and December, respectively. A trend of THC concentrations is not evident at these two stations.

5. INTERMITTENT MONITORING RESULTS

Data analysis has been conducted on intermittent air quality data to resolve, on a monthly basis, the maximum, minimum and mean loadings of specified parameters. A trend analysis was also performed on annual average parameter loadings using Daniel's trend test. This test is described in Section 4.

5.1 TOTAL SUSPENDED PARTICULATES (TSP)

5.1.1 Characteristics

Air pollutants are not only in the gaseous form. Tiny particles of solid material or liquid droplets, defined collectively as particulates, are also present in the air in great numbers, and may constitute an air pollution problem. The particles range in size from 0.001 to 500 microns (a human hair is about 100 microns in diameter) and, depending on their size and other properties, may remain suspended in the air for a few seconds or indefinitely.

In general, particles smaller than one micron in diameter originate in the atmosphere principally through condensation and combustion. Particles between 1 micron and 10 microns in diameter usually include soil, process dusts, and combustion products from industries. Particles larger than 10 microns in diameter generally result from mechanical processes such as wind erosion, grinding, spraying and vehicular activity.

Suspended particulates may result from a variety of natural and man-made sources. These include soil, road dust, dust resulting from other human activities (i.e., agriculture), smoke from forest fires, smoke from recreational sources (i.e., camp fires and fireplaces), vehicular exhaust emissions, and industrial emission sources.

5.1.2 Method of Monitoring

Suspended particulate matter is measured by the high-volume sampler. The sampler consists of a vacuum system and filter housed in a shelter and operates on the same principle as a vacuum cleaner. The TSP matter in the atmosphere is collected by drawing a known volume of air through a pre-weighed filter for a 24-hour period every sixth day according to the NAPS monitoring schedule. The filter is then reweighed to determine the mass of the particles collected.

5.1.3 Regulations and Guidelines

Regulations governing the maximum permissible levels of TSP are based on visibility reduction and nuisance effects. Alberta has adopted the most rigorous federal standards for maximum TSP loadings:

- ▲ 100 $\mu\text{g}/\text{m}^3$ (micrograms per cubic meter) as a 24-hour total loading; and
- ▲ 60 $\mu\text{g}/\text{m}^3$ as an annual geometric mean loading.

5.1.4 Results

In 1992, suspended particulates were monitored at all three Edmonton and Calgary monitoring stations, and at Fort Saskatchewan and Ellerslie monitoring locations. Monitoring of suspended particulates was discontinued at Ellerslie in October of 1991. Minimum, mean and maximum TSP loadings are presented by month in Figures 5-1 to 5-3.

Annual average loadings of TSP ranged from 28.1 $\mu\text{g}/\text{m}^3$ at Fort Saskatchewan to 70.7 $\mu\text{g}/\text{m}^3$ at the Calgary industrial monitoring location. Urban monitoring stations located in Edmonton and Calgary showed notably higher TSP loadings than the Fort Saskatchewan station.

5.1.4.1 Edmonton

Exceedances of the 24-hour regulation for TSP were recorded at all Edmonton stations in 1992. A total of nine, two and three exceedances occurred at the central, northwest and east stations, respectively. Annual average TSP loadings ranged from 42.3 $\mu\text{g}/\text{m}^3$ at the northwest station to 58.1 $\mu\text{g}/\text{m}^3$ at the central station. Higher TSP loadings at the central station are likely due to a greater traffic density than the northwest and east monitoring locations. The highest frequency of exceedances were recorded in the late winter and early spring seasons. Exceedances during these seasons may be attributed to: (1) the combination of vehicle emissions with persistent inversions which do not allow pollutants to disperse rapidly; or (2) resultant sand and dust which is evident on most streets after spring thaw. A peak 24-hour TSP loading of 174.4 $\mu\text{g}/\text{m}^3$ was observed at the Edmonton central monitoring unit in February. The annual average regulation for TSP of 60 $\mu\text{g}/\text{m}^3$ was not exceeded at any Edmonton monitoring stations. A decrease in annual average TSP loading is indicated at the central and northwest monitoring stations.

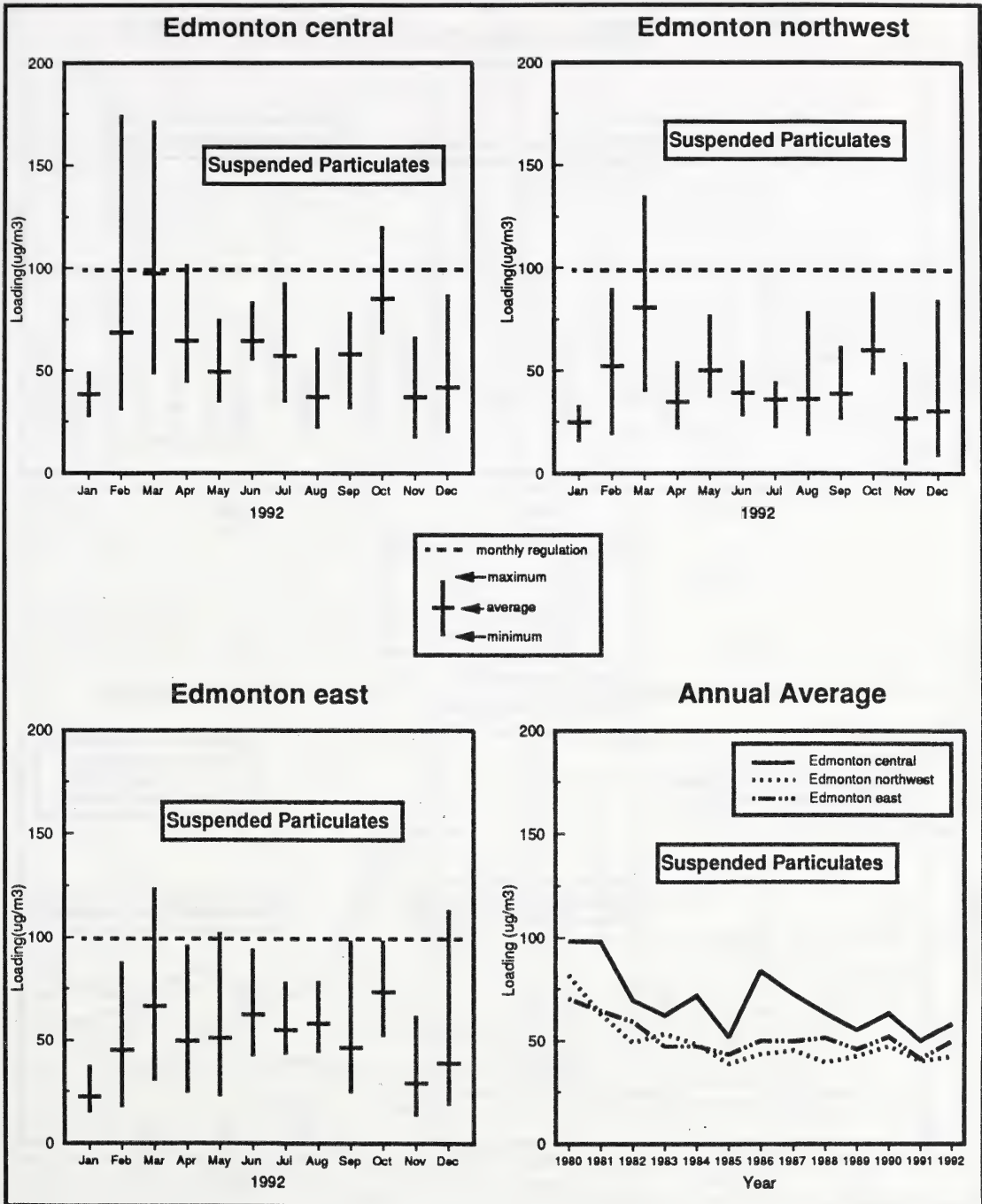


Figure 5-1 Total suspended particulate loadings at Edmonton.

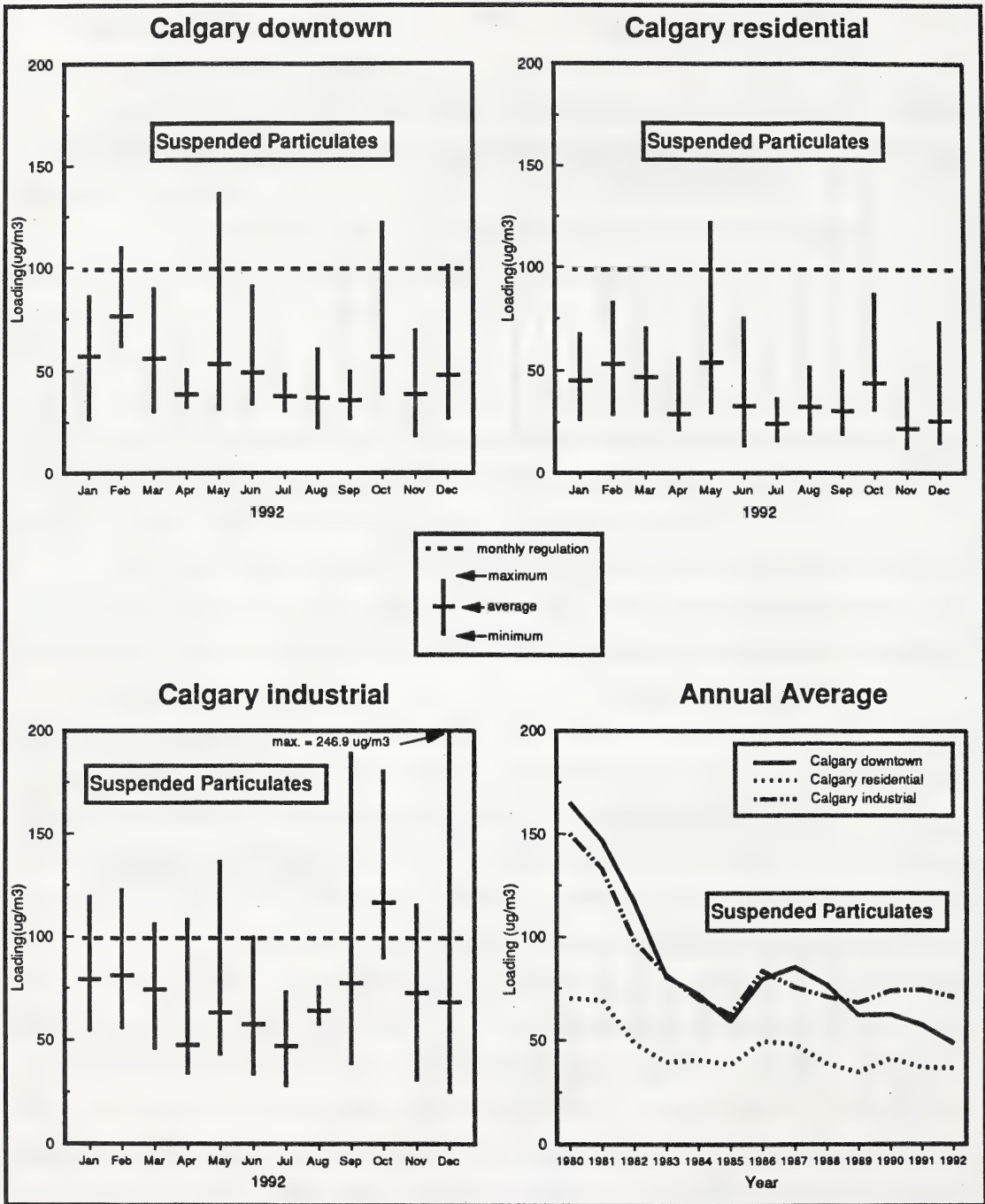


Figure 5-2 Total suspended particulate loadings at Calgary.

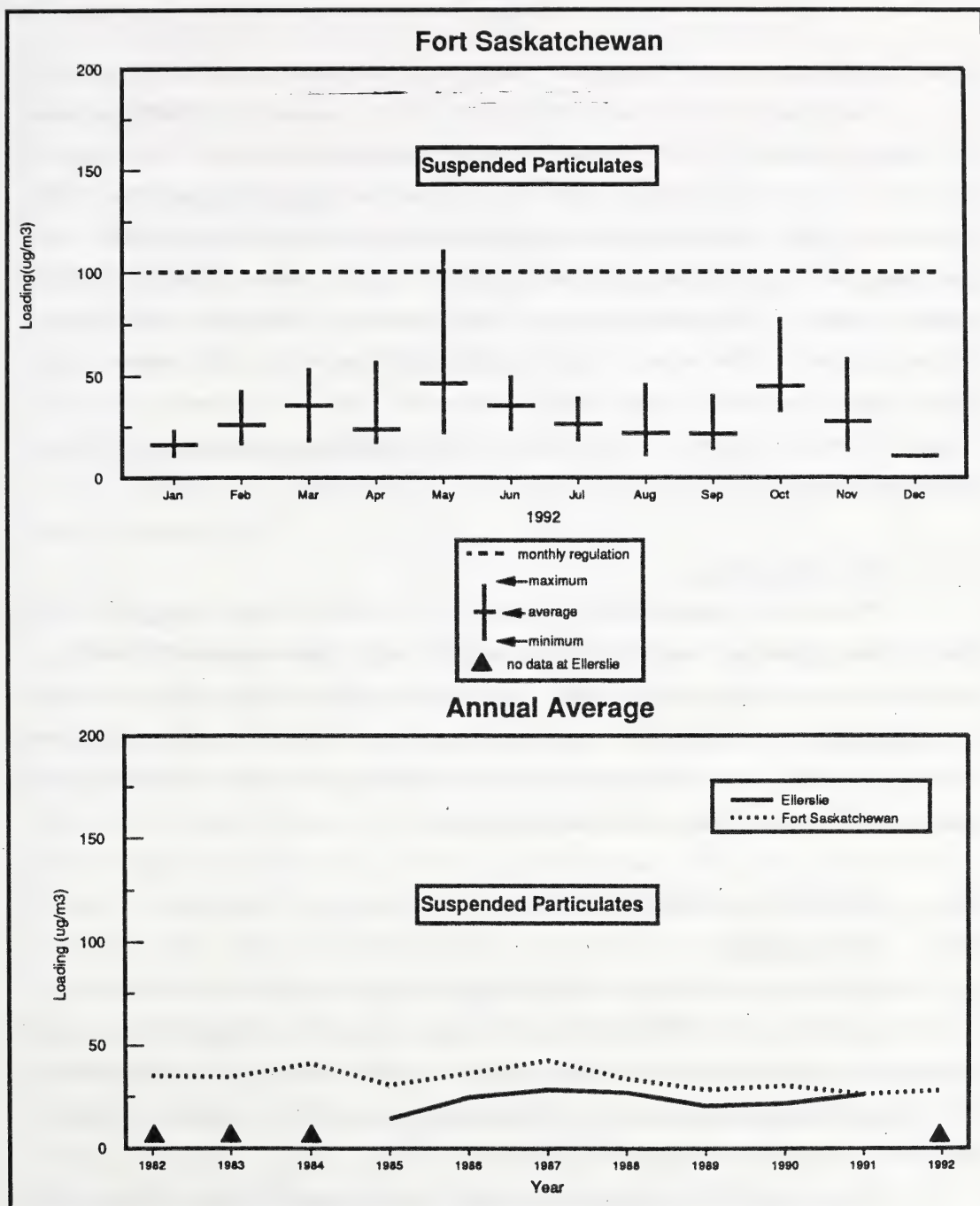


Figure 5-3 Total suspended particulate loadings at Fort Saskatchewan.

5.1.4.2 Calgary

Exceedances of the 24-hour regulation for TSP were recorded relatively frequently at the industrial monitoring location. A total of twelve exceedances occurred at this location in 1992. The 24-hour regulation of 100 ug/m^3 was exceeded four times at the downtown station and one time at the residential station. Exceedances were observed in at least 20% of the observations in every month except July and August at the industrial station. The maximum TSP loading observed in Calgary was 246.9 ug/m^3 which occurred in December at the industrial monitoring location. The annual average regulation of 60 ug/m^3 was also exceeded at the Calgary industrial monitoring station where a value of 70.7 ug/m^3 was observed. A significant decrease in annual average total suspended particulate loadings is evident at all Calgary monitoring stations.

5.1.4.3 Fort Saskatchewan

The 24-hour regulation for TSP loading was exceeded one time in May at the Fort Saskatchewan high-volume monitoring station in 1992. An overall maximum TSP loading of 110.9 ug/m^3 was measured at this location. On average, the highest TSP values were recorded in the spring and fall at the Fort Saskatchewan station. A major source of suspended particulates at this location may be road and agricultural dust. A trend towards lower annual average TSP loadings is detectable at the Fort Saskatchewan station.

5.2 BENZO (a) PYRENE (BaP)

5.2.1 Characteristics

BaP is an organic compound that belongs to a class of compounds known as polycyclic aromatic hydrocarbons (PAH). BaP is formed during the combustion of organic materials and is present in all types of soot and smoke. The prime sources are heat and power generation, refuse burning, coke production and motor vehicle emissions. BaP has also been detected in tobacco smoke, wood smoke from fireplaces and forest fires.

Most sources of BaP have not been accurately characterized because of the variety of factors that influence BaP formation. For example, during the process of combustion, the amount

of excess air, combustion temperature, fuel moisture content and feed conditions will affect the formation of BaP.

5.2.2 Method of Monitoring

BaP is monitored every sixth day at all high-volume monitoring stations according to the NAPS monitoring schedule. High-volume filters undergo laboratory analysis to quantify the amount of BaP in the sample. The result is a 24-hour accumulated loading of BaP expressed in micrograms per 1000 cubic meters ($\mu\text{g}/1000 \text{ m}^3$).

5.2.3 Regulations and Guidelines

Alberta Environmental Protection does not currently have regulations or guidelines for ambient loadings of BaP.

5.2.4 Results

BaP was monitored at all three Edmonton and Calgary air quality monitoring stations as well as at the Fort Saskatchewan monitoring unit. A seasonal trend in BaP loadings is obvious based on these data at all monitoring stations. Much higher loadings of BaP were evident in the late fall and winter than in the spring and summer seasons. Relatively low BaP loadings were observed in the summer months at all stations. During the winter, meteorological conditions that retard the dispersion of pollutants, such as inversions and low wind speeds, tend to be more prevalent. A second contributing factor is that automobile engines run less efficiently during cold temperatures which leads to an increase in BaP emissions from automobiles.

Annual average BaP loadings ranged from $0.04 \mu\text{g}/1000 \text{ m}^3$ at the Edmonton east, Calgary residential and Fort Saskatchewan stations to $0.15 \mu\text{g}/1000 \text{ m}^3$ at the Edmonton central station. Annual average BaP loadings are much higher at monitoring stations located in the vicinity of heavily used traffic arteries. Annual average BaP values were substantially lower in 1991 and 1992 than in previous years at most stations. Minimum, maximum and mean BaP loadings are presented in Figures 5-4 to 5-6 for each monitoring station.

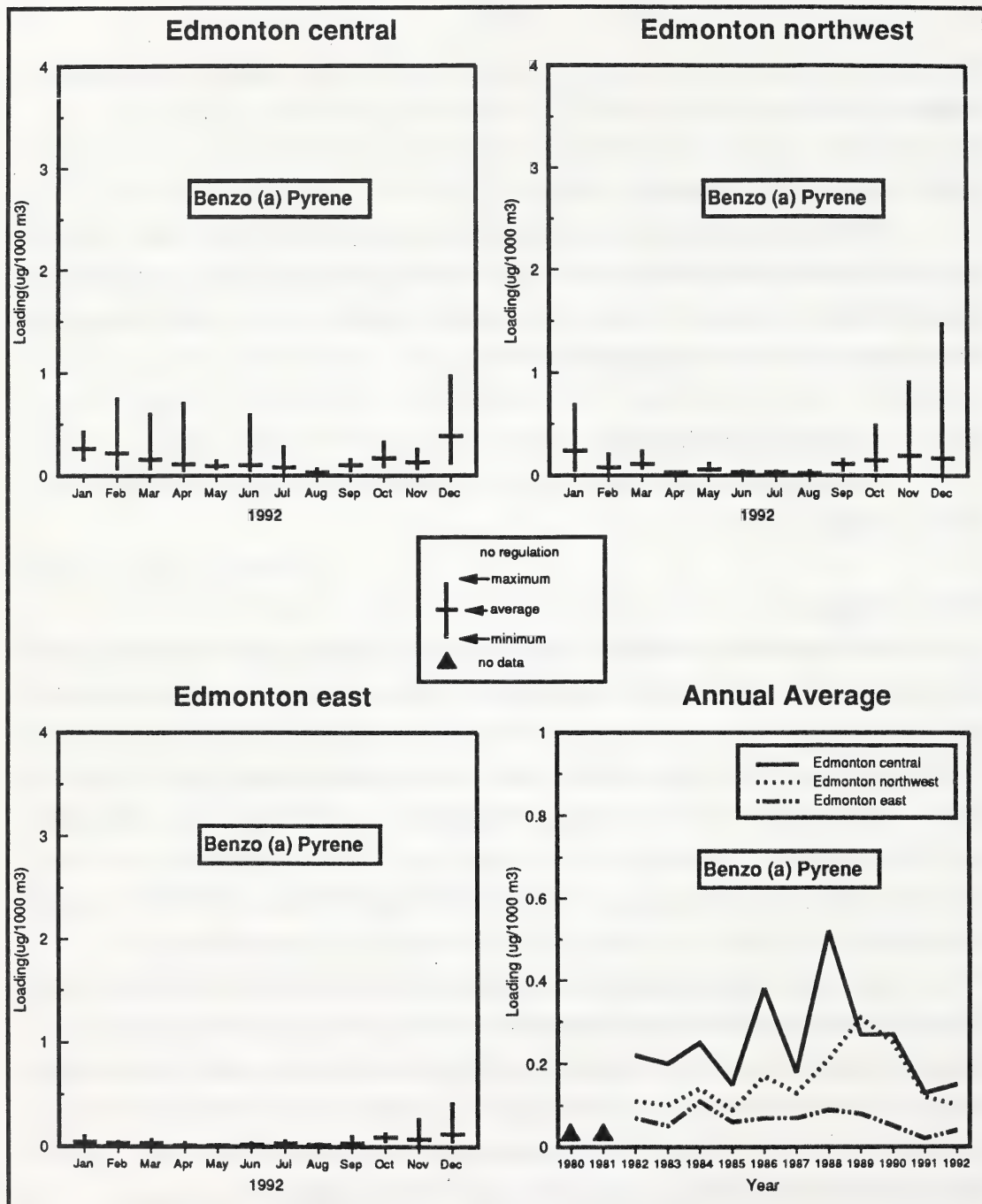


Figure 5-4 Benzo (a) Pyrene loadings at Edmonton.

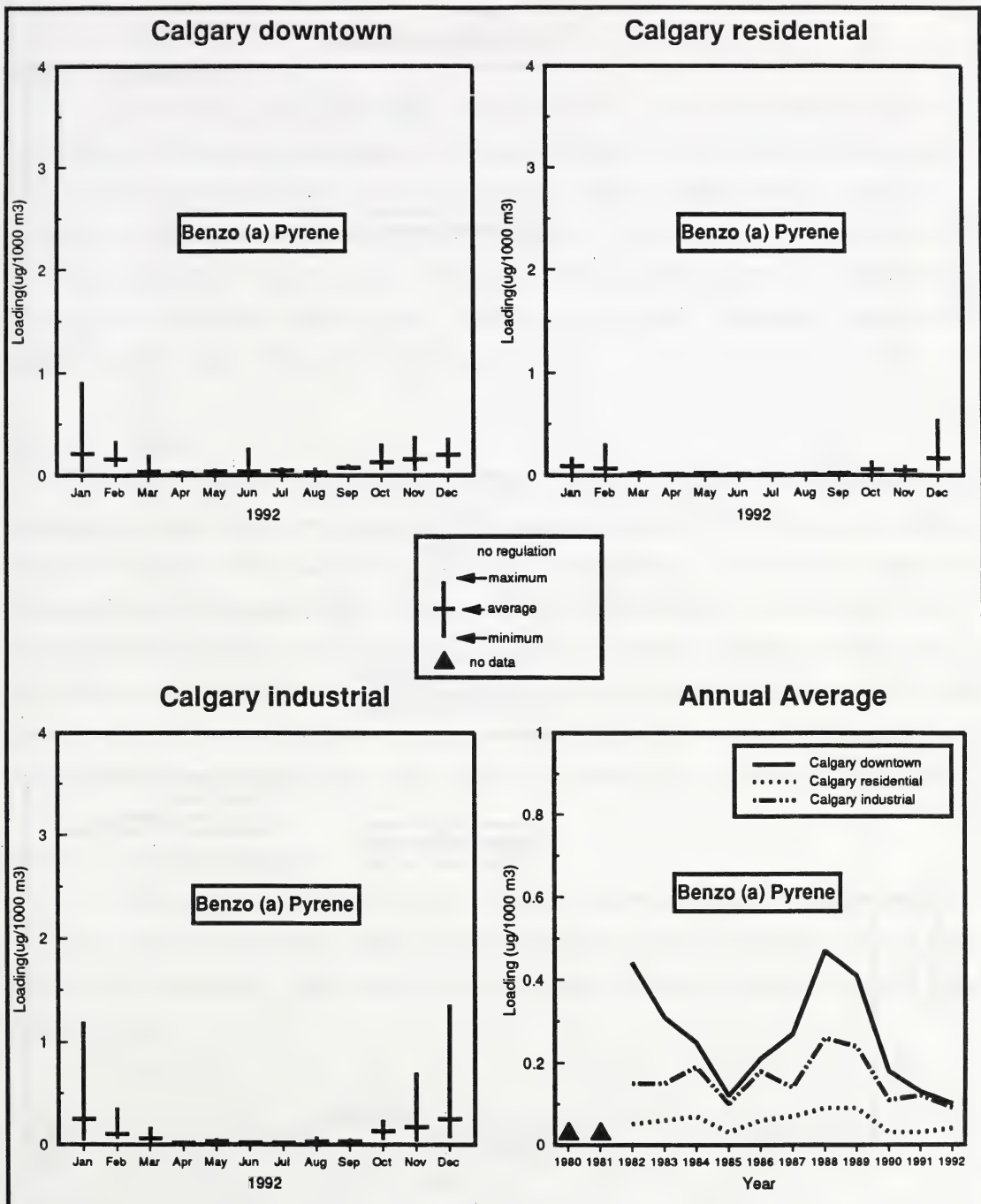


Figure 5-5 Benzo (a) Pyrene loadings at Calgary.

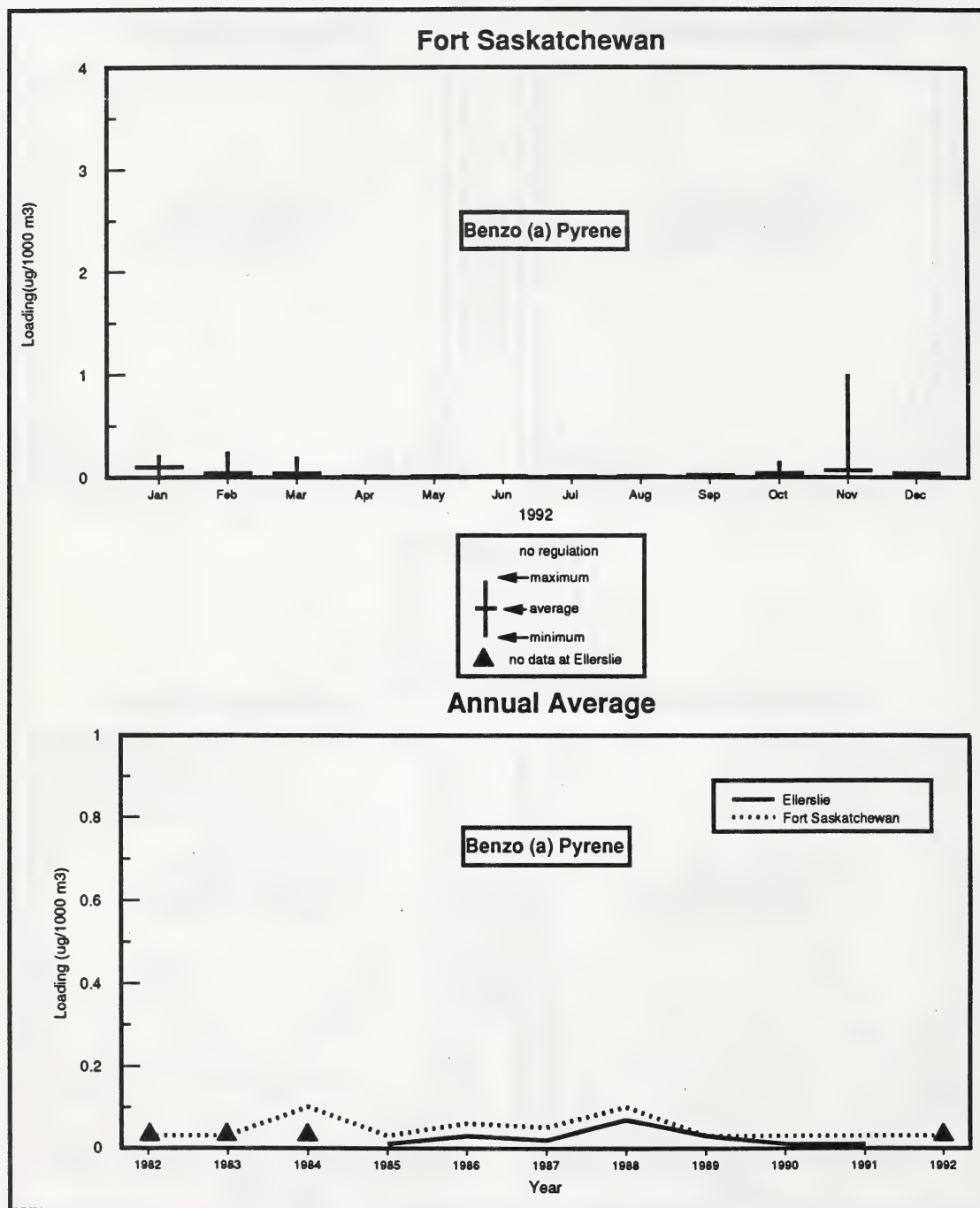


Figure 5-6 Benzo (a) Pyrene loadings at Fort Saskatchewan.

5.2.4.1 Edmonton

BaP loadings were much higher at the central and northwest monitoring stations in comparison to the east monitoring station. Substantially higher vehicular traffic is evident in the vicinity of the central and northwest monitoring stations. Vehicular emissions are a major source of BaP. A maximum BaP loading of $1.49 \text{ ug}/1000 \text{ m}^3$ was observed in December at the Edmonton northwest monitoring station. BaP does not show a significant trend in annual average loadings based on eleven years of data. However, lower annual average BaP values were indicated in 1991 and 1992 than in previous years.

5.2.4.2 Calgary

BaP loadings at the Calgary downtown and industrial monitoring stations were substantially higher than those recorded at the residential station in 1992. Vehicular traffic in downtown Calgary is likely the major source of BaP at this location. The transport of pollutants from downtown Calgary may be a major contributor to BaP loadings at the industrial station. Vehicle traffic on Deerfoot Trail, which is located to the east of the industrial monitoring station, may also contribute to BaP values at this location. A peak BaP loading of $1.36 \text{ ug}/1000 \text{ m}^3$ was recorded in December at the Calgary industrial monitoring location. A trend in annual average BaP loadings is not evident at any Calgary monitoring stations based on eleven years of data.

5.2.4.3 Fort Saskatchewan

BaP loadings at Fort Saskatchewan were much lower than in downtown Edmonton and Calgary. The maximum BaP loading at Fort Saskatchewan was $1.0 \text{ ug}/1000 \text{ m}^3$ which was observed in November. BaP does not show a trend in annual average values at Fort Saskatchewan.

5.3 LEAD (Pb)

5.3.1 Characteristics

Lead in the ambient air exists primarily as particulate matter of inhalable size. Atmospheric lead results predominantly from man-made processes such as the operation of motor vehicles, iron and steel production, solid waste incineration and battery manufacturing. The burning of leaded gasoline by motor vehicles was the largest source of lead in the atmosphere. Lead is emitted from vehicle exhaust in the form of lead vapours, lead alkyls, very fine lead particles and organic halogens such as lead bromide, lead chloride and lead bromochloride. These compounds originate from the lead anti-knock additives used in gasoline.

In Canada, automobile emissions of lead have steadily increased from 2600 tonnes in 1948 to a peak of 14,360 tonnes in 1973. The introduction of unleaded gasoline coupled with restrictions on the lead content in leaded gasoline has resulted in a general decrease in the quantity of lead emitted into the atmosphere.

The next phase in reducing lead levels in leaded gasoline took place on January 1, 1987 when the amount of lead added to gasoline was reduced by one-third. Since September 1987 all new model light-duty vehicles were required to be equipped with catalytic converters which allow only the use of unleaded fuel.

5.3.2 Method of Monitoring

Lead is monitored every sixth day at all high-volume monitoring stations according to the NAPS monitoring schedule. High-volume filters undergo laboratory analysis to quantify the amount of lead in the sample. The result is a 24-hour accumulated loading of lead expressed in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

5.3.3 Regulations and Guidelines

Alberta currently regulates lead emissions by licencing each source and limiting their emissions according to the Clean Air (Maximum Levels) Regulation.

5.3.4 Results

Lead was monitored at all high-volume monitoring stations in 1992. Lead loadings were substantially greater at monitoring stations located close to areas with a high traffic density. Annual average lead loadings were 0.01 ug/m^3 at all stations except for Edmonton central and Calgary industrial where values of 0.02 ug/m^3 were recorded. Seasonal trends in lead loadings are difficult to detect.

Relatively low lead loadings were recorded at all stations compared to previous years. A substantial decrease in annual average lead loadings is evident from 1989 to 1992. This notable trend may reflect the suspended sale of leaded gasoline at gas stations in 1990. A long-term trend towards lower lead loadings is indicated at all monitoring stations. This is a reflection of a substantial decrease of lead additives in gasoline over the past 10 years. Figures 5-7 to 5-9 show the mean, maximum and minimum lead loadings by month at each of the monitoring stations.

5.3.4.1 Edmonton

Lead loadings were generally greater at the Edmonton central monitoring station than at the northwest and east monitoring stations, however, lead loadings were low at all stations. Peak lead loadings at the central, northwest and east monitoring stations were 0.13, 0.06 and 0.09 ug/m^3 in 1992. This is compared to peak values of 0.52, 0.50 and 0.19 ug/m^3 , respectively, at these stations in 1991.

5.3.4.2 Calgary

Maximum lead loadings at the Calgary monitoring stations were 0.05 (downtown), 0.04 (residential) and 0.12 ug/m^3 (industrial). These peak values are again substantially lower than those observed in 1991. Peak values of 0.15, 0.08 and 0.28 ug/m^3 were observed at the downtown, residential and industrial stations, respectively, in 1991. Significantly higher lead loadings were recorded at the industrial station than at the downtown and residential stations.

5.3.4.3 Fort Saskatchewan

Lead loadings were very low at the Fort Saskatchewan monitoring station in 1992. The peak lead loading at this location was 0.03 ug/m^3 . This is compared to a value of 0.16 ug/m^3 recorded in 1991 at the Fort Saskatchewan station.

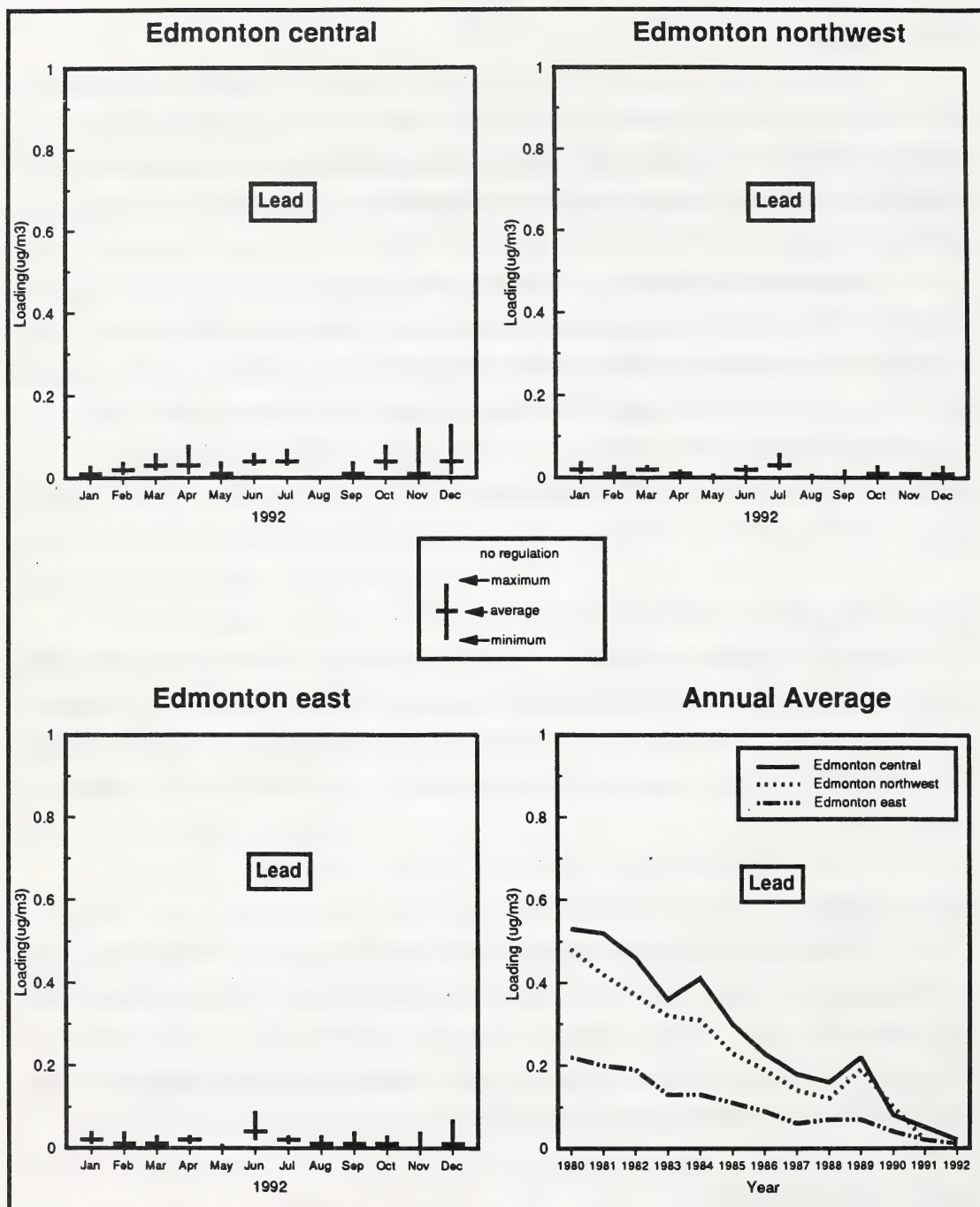
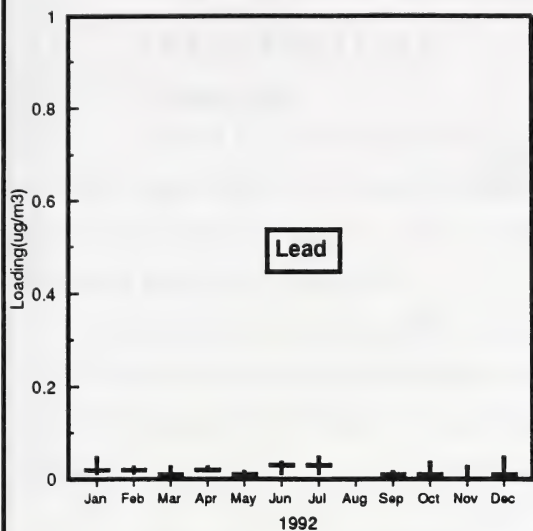
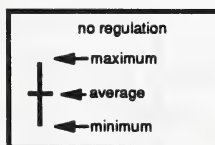
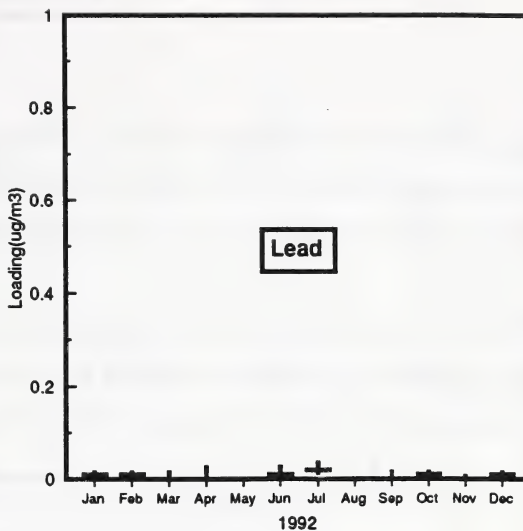


Figure 5-7 Lead loadings at Edmonton.

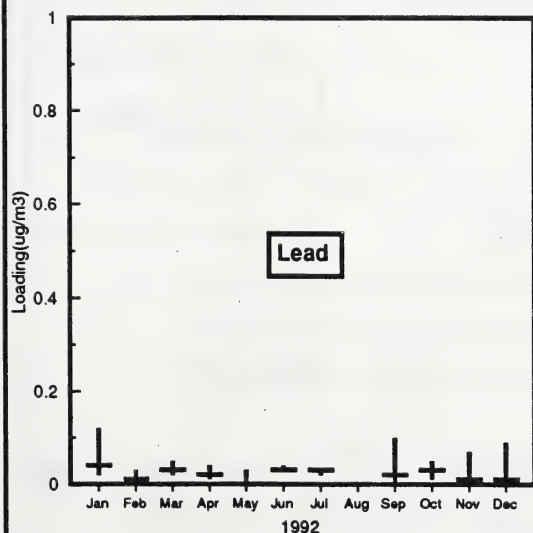
Calgary downtown



Calgary residential



Calgary industrial



Annual Average

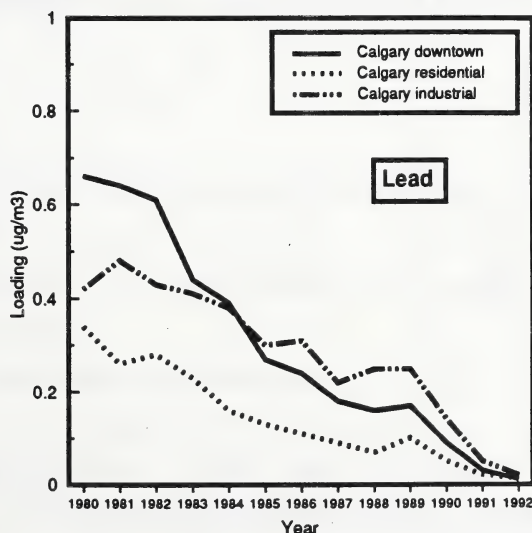


Figure 5-8 Lead loadings at Calgary.

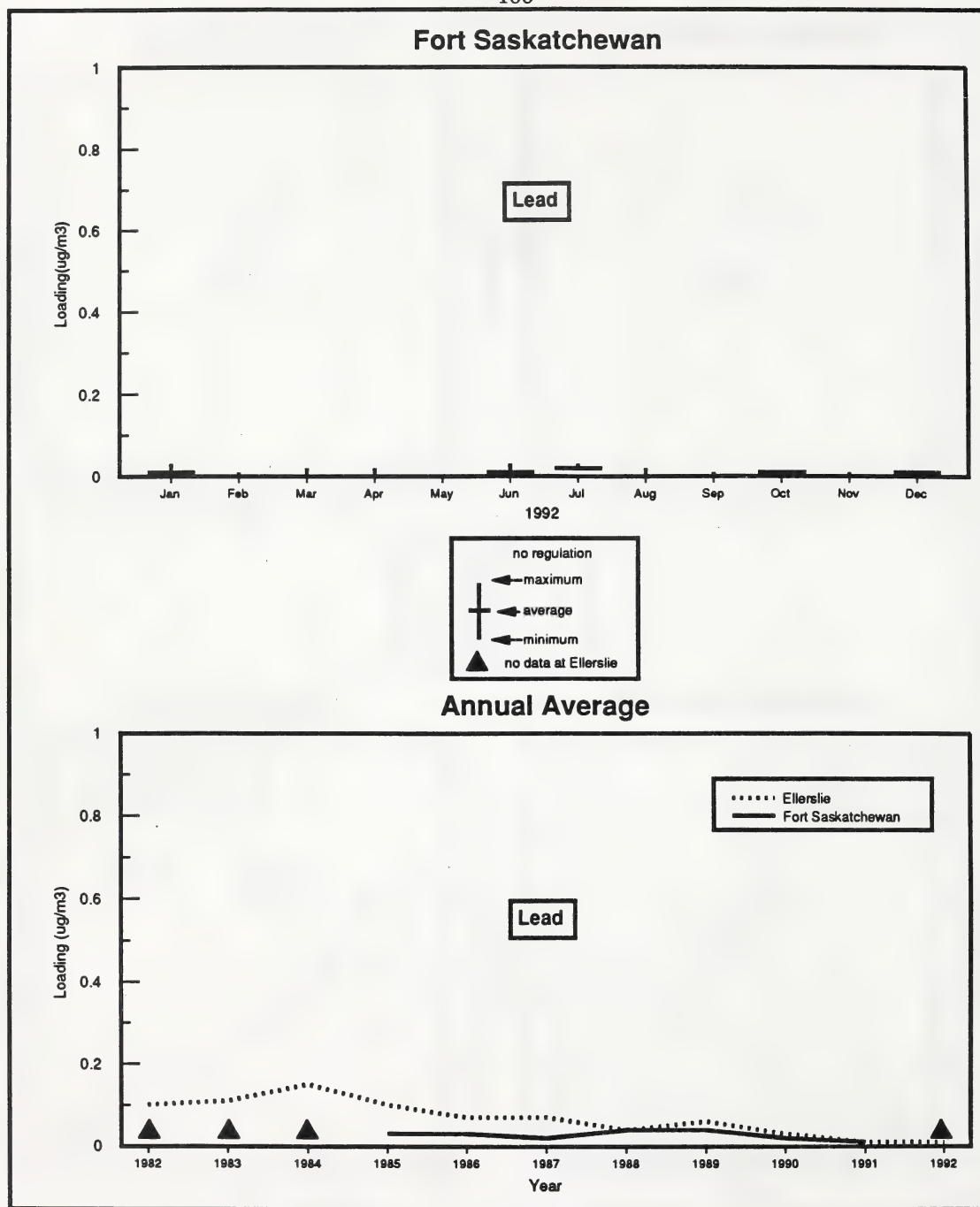


Figure 5-9 Lead loadings at Fort Saskatchewan.

6. STATIC MONITORING RESULTS

6.1 TOTAL DUSTFALL

6.1.1 Characteristics

Dustfall is described as a measurement of the fraction of particulate matter that does not remain suspended in the atmosphere for an indefinite period of time. Particles collected by dustfall monitors will generally have a larger diameter and mass than those collected as suspended particles (see Section 5.1).

Dustfall may originate from a variety of natural and man-made sources. The most common sources are road dust, wind-blown soil, particles generated through agricultural activities (harvest), large particles emanating from industrial sources and ash from forest and recreational fires.

6.1.2 Method of Monitoring

Total dustfall is collected in a vertically erected cylinder containing either water (in the summer) or iso-propyl alcohol (in the winter). Particles settle into the cylinder and onto the surface of the liquid. The liquid serves the purpose of keeping particles from blowing out of the container. At the end of the one-month monitoring period, the sample is analyzed to determine the total dustfall loading.

6.1.3 Regulations and Guidelines

The regulations adopted by Alberta Environmental Protection for total dustfall in the ambient air are as follows:

- ▲ 53 mg/100 sq cm/30 days (milligrams per 100 square centimeters per 30 days) in residential and recreational areas; and
- ▲ 158 mg/100 sq cm/30 days in commercial and industrial areas.

6.1.4 Results

Dustfall was monitored at 13 networks by Alberta Environmental Protection in 1992. Each network consist of at least one monitoring station which collects total dustfall as an accumulated loading for a period of one month. A total of 57 total dustfall monitoring stations were operated at these networks during 1992. Figure 6-1 shows the location of total dustfall monitoring networks in Alberta. Table 6.1 summarizes the arithmetic average of total dustfall

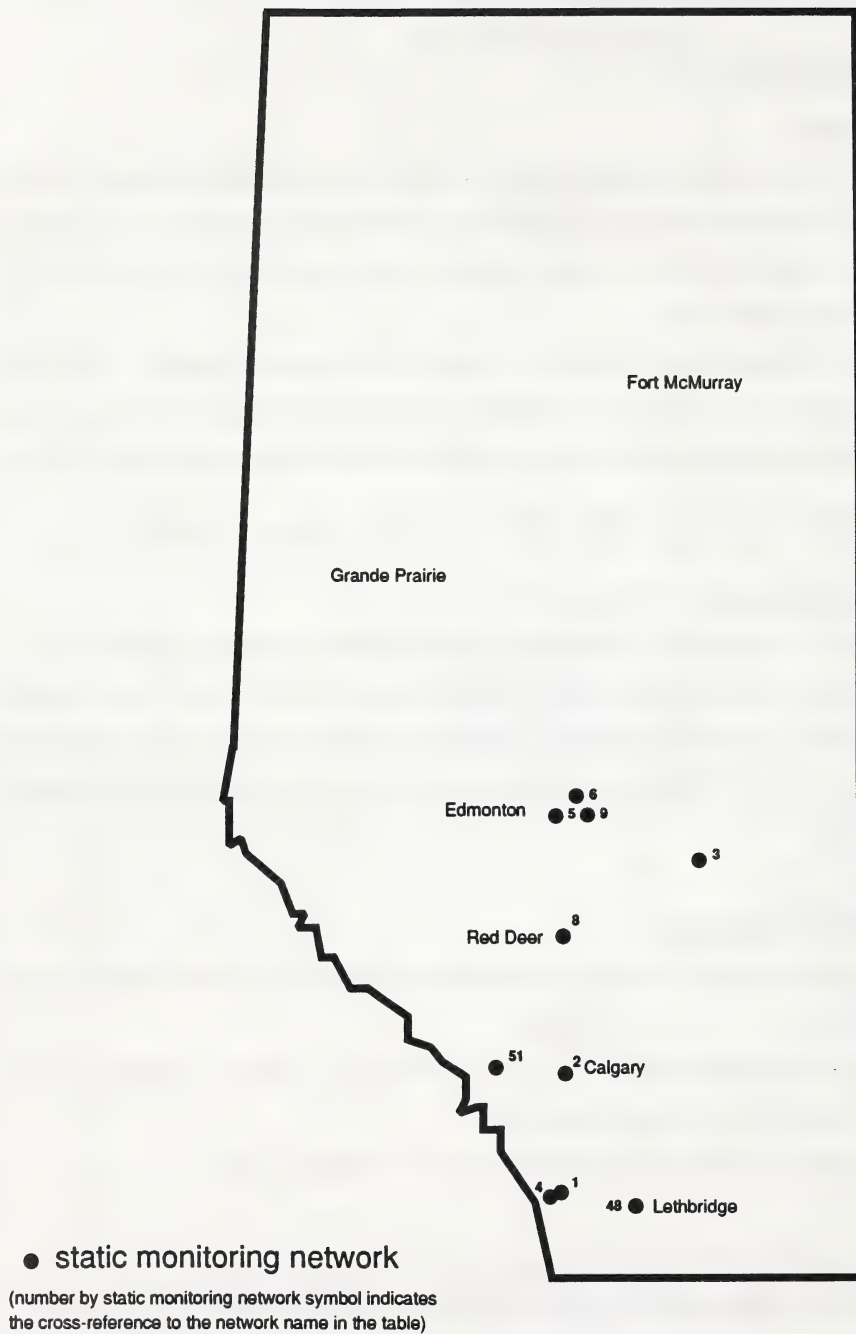


Figure 6-1 Location of total dustfall monitoring networks.

Table 6.1 Averages and exceedances from networks which monitor total dustfall.

Network Location	# of Stations	Average (mg/100 sq cm/30 days)	Exceedances (percent)		Map Location
			a	b	
Blairmore	2	45	30	4	1
Calgary	3	67	50	4	2
Camrose	1	30	9	0	3
Coleman	11	47	20	2	4
Edmonton	26	60	37	6	5
EDMU	1	94	83	8	5
EIMU	1	28	0	0	5
ERMU	1	22	0	0	5
Exshaw	5	55	29	8	51
Fort Saskatchewan (special)	1	16	0	0	6
Lethbridge	1	137	92	50	48
Red Deer	1	**	**	**	8
Sherwood Park	3	40	19	3	9

a Refers to exceedances of the residential/recreational regulation (53 mg/100 sq cm/30 days).

b Refers to exceedances of the industrial/commercial regulation (158 mg/100 sq cm/30 days).

* ≥50 to <75% of data available.

** Less than 50% of data available.

na No data available.

loadings for each network as well as the frequency of time total dustfall loadings exceeded residential/recreational and industrial/commercial regulations at each network.

Average total dustfall loadings ranged from 16 mg/100 sq cm/30 days at Fort Saskatchewan to 137 mg/100 sq cm/30 days at Lethbridge. Relatively high annual average dustfall loadings were also measured at Calgary, Edmonton and EDMU (Edmonton central)

monitoring networks. Annual average values at these locations were 67, 60 and 94 mg/100 sq cm/30 days, respectively. The highest frequency of exceedances of the residential/recreational regulation for total dustfall were observed at the Lethbridge (92%), Edmonton central (83%) and Calgary (50%) monitoring networks. The industrial/commercial regulation was exceeded most frequently at Lethbridge network where 50% of observations were greater than 158 mg/100 sq cm/30 days. Exceedances of the residential/recreational and industrial/commercial regulations were not recorded at the Edmonton northwest, Edmonton east or Fort Saskatchewan monitoring locations.

6.2 CALCIUM

6.2.1 Characteristics

The most common natural sources of calcium are wind-blown soil and road dust. Calcium is emitted as particulate matter from processes used in cement, iron, steel, wood and coal manufacturing. The most common compounds of calcium that occur in particulate matter are limestone and gypsum (Alberta Environment 1985; Environment Canada 1984).

6.2.2 Method of Monitoring

Calcium loadings are obtained by laboratory analysis of the dustfall samples. Analysis for calcium is generally performed on total dustfall samples collected from stations located close to facilities which emit calcium into the atmosphere (i.e., cement processing plants).

6.2.3 Regulations and Guidelines

There are no regulations or guidelines for atmospheric calcium loadings in Alberta at the present time.

6.2.4 Results

Figure 6-2 indicates the locations where calcium was monitored in 1992. Table 6.2 shows the average and maximum calcium loadings for each network. Average calcium loadings ranged from 0.5 mg/100 sq cm/30 days at the Edmonton northwest monitoring station to 5.2 mg/100 sq cm/30 days at the Exshaw monitoring network. A maximum calcium loading of

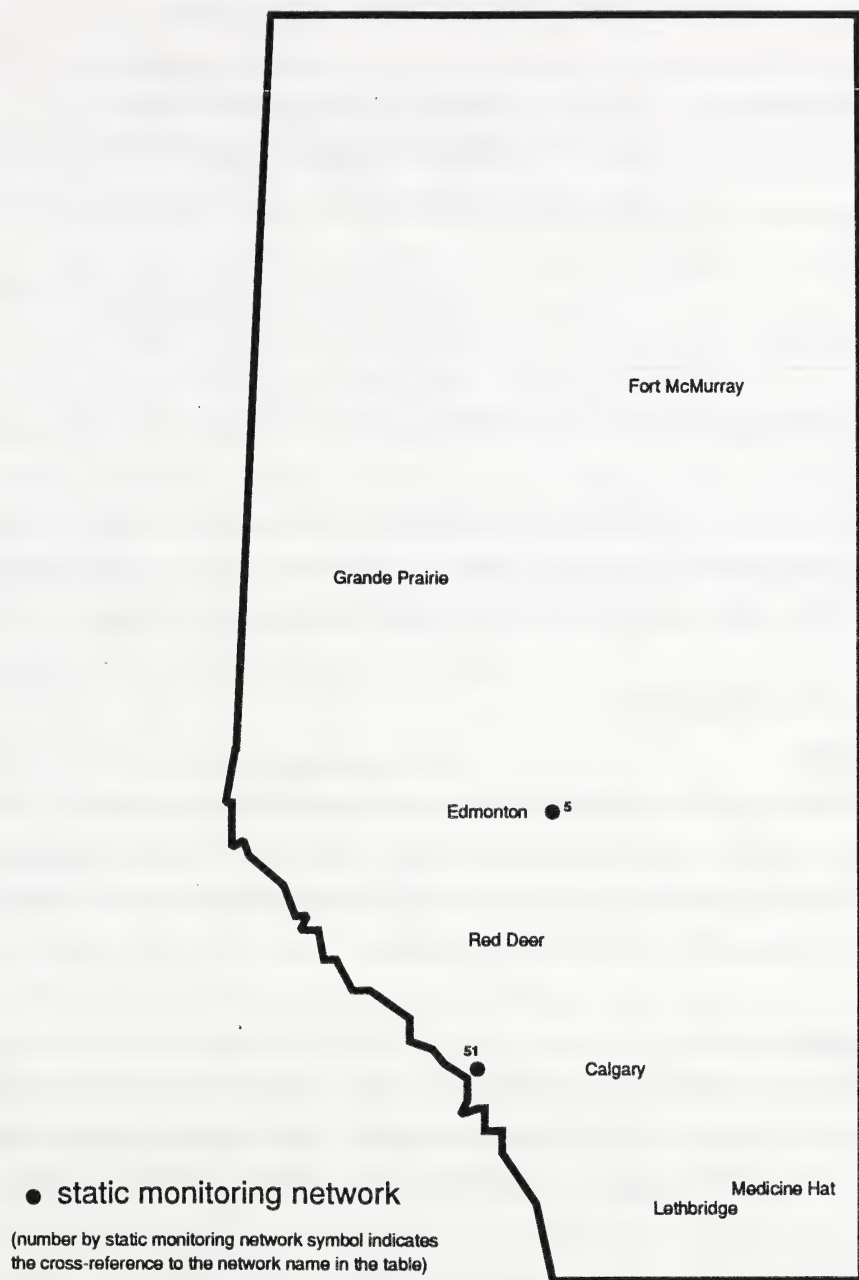


Figure 6-2 Location of calcium monitoring networks.

Table 6.2 Averages and maximums from networks which monitor calcium.

Network Location	# of Stations	Average (mg/100 sq cm/30 days)	Maximum (mg/100 sq cm/30 days)	Map Location
Edmonton	3	3.0	9.8	5
EIMU	1	1.0	1.6	5
ERMU	1	0.5	1.1	5
Exshaw	5	5.2	40.9	51

40.9 mg/100 sq cm/30 days was measured at the Exshaw monitoring network in 1992. The location of the Exshaw monitoring network relative to limestone deposits and a cement manufacturing plant likely explain the relatively high calcium loadings in the vicinity.

6.3 TOTAL SULPHATION

6.3.1 Characteristics

Total sulphation includes all sulphur-containing compounds which are present in the ambient air. These compounds include hydrogen sulphide, sulphur dioxide and mercaptans. Sources of sulphur-containing compounds include emissions from sulphur recovery processes at sour gas plants and as a by-product of fossil fuel combustion.

6.3.2 Method of Monitoring

Total sulphation is measured by a sulphation cylinder or a sulphation plate which has a surface that is impregnated with a reactive potassium carbonate. Sulphur compounds react with potassium carbonate and laboratory analysis is conducted on the sample to determine sulphate loading.

6.3.3 Regulations and Guidelines

The guideline for total sulphation loading in Alberta is:

- ▲ 0.50 mg SO₃ equivalent/day/100 sq cm (milligrams as SO₃ per day per 100 square centimetres).

6.3.4 Results

Total sulphation is monitored at 20 networks, on a one-month basis, and 35 networks, on a three-month basis, throughout the province. The length of the exposure period is dependent on the abundance and type of industrial sources in the area.

6.3.4.1 One-Month Exposure Period

A total of 82 static monitoring stations at 20 networks measured total sulphation, on a one-month basis in Alberta during 1992. The locations of these networks are indicated in Figure 6-3. The average total sulphation for each network and frequency of exceedances for each network is shown in Table 6.3. There were no exceedances of the regulation for stations which monitor total sulphation on a monthly basis. Average total sulphation values ranged from 0.007 mg/day/100 sq cm at Hinton to 0.080 mg/day/100 sq cm at Fort Saskatchewan. The maximum total sulphation loading from these networks was 0.225 mg/day/100 sq cm which occurred at the Redwater monitoring network.

6.3.4.2 Three-Month Exposure Period

A total of 137 stations monitor total sulphation, on a three-month basis, in 35 static monitoring networks in Alberta. The locations of these networks are presented in Figure 6-4. Table 6.4 shows average total sulphation values for each network and the frequency of exceedances for each network. On average, the lowest total sulphation loadings occurred at the Lone Pine Creek, Okotoks, Pincher Creek and Quirk Creek networks. Annual average loadings at these stations ranged from 0.026 to 0.028 mg/day/100 sq cm. The highest annual average loadings occurred at the Diamond Valley and Redwater networks where values of 0.165 and 0.153 mg/day/100 sq cm were observed, respectively. The guideline for total sulphation of was exceeded one time at the Diamond Valley monitoring network where a value of 2.050 mg/day/100 sq cm was observed. Relatively high total sulphation observations in the vicinity of Diamond Valley was likely the result of gas processing activities in the area. The guideline was not exceeded at any other monitoring locations.

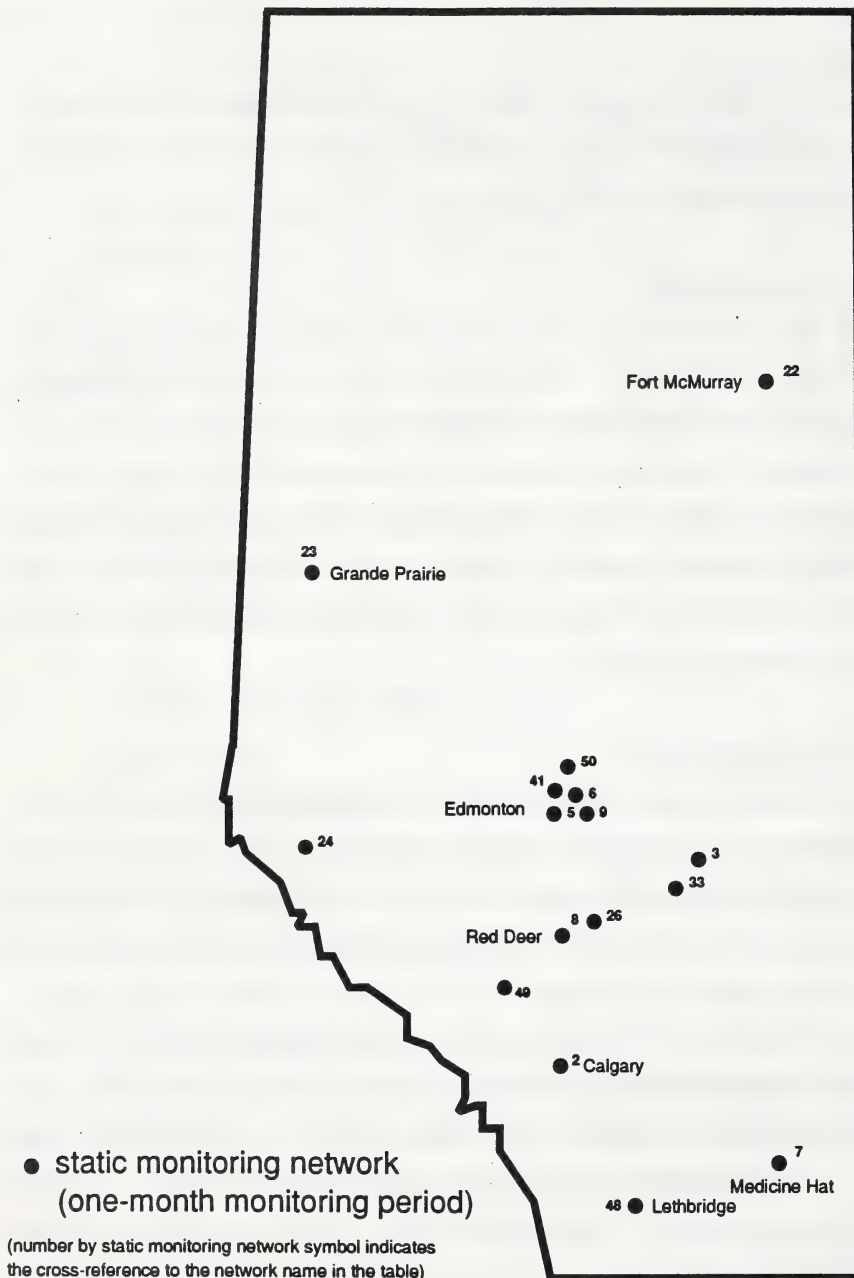


Figure 6-3 Location of total sulphation monitoring networks.

Table 6.3 Averages and exceedances from networks which monitor total sulphation on a one-month exposure basis.

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent) ^a	Map Location
Calgary	11	0.049	0	2
Camrose	1	0.042	0	3
Edmonton	26	0.043	0	5
EDMU	1	0.023	0	5
EIMU	1	0.054	0	5
ERMU	1	0.042	0	5
Fort McMurray	6	0.054*	0*	22
Fort Saskatchewan	4	0.080	0	6
Fort Saskatchewan (special)	1	0.059	0	6
Grande Prairie	1	0.011	0	23
Hinton	3	0.007	0	24
Joffre	2	**	**	26
Lethbridge	5	0.023	0	48
Medicine Hat	4	0.023	0	7
New Norway	1	**	**	33
Raven Brood	3	0.016*	0*	49
Red Deer (city)	2	**	**	8
Redwater	4	0.060	0	50
Sherwood Park	3	0.061	0	9
St. Albert	2	0.012	0	41

^a Refers to exceedances of the guideline (0.50 mg/day/100 sq cm).

* ≥50 to <75% of data available.

** Less than 50% of data available.

na No data available.



Figure 6-4 Location of total sulphation monitoring networks.

Table 6.4 Averages and exceedances from networks which monitor total sulphation on a three-month exposure basis.

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent) ^a	Map Location
Balzac	4	0.058	0	10
Bigstone	2	na	na	12
Blue Ridge	4	na	na	13
Buck Lake	4	na	na	11
Caroline	1	na	na	14
Carstairs	4	0.030	0	16
Cochrane	4	0.051	0	15
Coleman	4	0.083	0	4
Crossfield	5	0.048	0	17
Diamond Valley	4	0.165	6	18
Didsbury	6	na	na	19
Edburg	1	na	na	20
Edson	4	0.038	0	21
Innisfail	3	na	na	25
Jumping Pound	4	0.036	0	27
Kaybob	4	na	na	28
Kaybob (south)	4	na	na	29
Lone Pine Creek	5	0.026	0	30
Mayerthorpe	2	na	na	31
Mazeppa	4	0.034	0	32
Nevis	7	na	na	34
Okotoks	5	0.026	0	35
Olds	4	na	na	36
Pincher Creek	6	0.027	0	37
Quirk Creek	6	0.028	0	38
Ram River	5	na	na	39
Red Deer	3	na	na	8
Redwater	4	0.153	0	50
Rimbey	4	na	na	40
Simonette	2	na	na	42
Sundre	2	na	na	43
Valleyview	2	na	na	44
Waterton	8	0.085	0	45
Wimborne	2	na	na	46
Windfall	4	na	na	47

^a Refers to exceedances of the guideline (0.50 mg/day/100 sq cm).

* ≥50 to <75% of data available.

** Less than 50% of data available.

na No data available.

6.4 HYDROGEN SULPHIDE (H_2S)

6.4.1 Characteristics

The characteristics of H_2S are described in Section 4.6 of this report. Industrial sources of H_2S include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process. H_2S occurs naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes.

6.4.2 Method of Monitoring

H_2S is monitored by an exposure cylinder or an exposure plate which contains a surface which has been impregnated with zinc acetate. H_2S will react with zinc acetate to form zinc sulphide. The quantity of zinc sulphide is proportional to the quantity of H_2S deposited onto the surface.

6.4.3 Regulations and Guidelines

The guideline for H_2S loading in Alberta is:

- ▲ 0.10 mg SO_3 equivalent/day/100 sq cm (milligrams as SO_3 per day per 100 square centimetres).

6.4.4 Results

H_2S is monitored on a one-month and three-month basis in the province. A total of 10 networks monitor H_2S on a one-month basis while 35 networks monitor H_2S on a three-month basis.

6.4.4.1 One-Month Exposure Period

A total of 22 static monitoring stations measure H_2S , on a one-month basis in Alberta. Figure 6-5 shows the location of these networks. Average H_2S loadings and exceedances of the guideline for each network are shown in Table 6.5. Average H_2S loadings ranged from 0.006 mg/day/100 sq cm at Hinton and Grande Prairie to 0.018 mg/day/100 sq cm at Fort McMurray. Relatively high annual average H_2S loadings were also recorded at Fort Saskatchewan and Sherwood Park where values of 0.017 and 0.014 mg/day/100 sq cm were

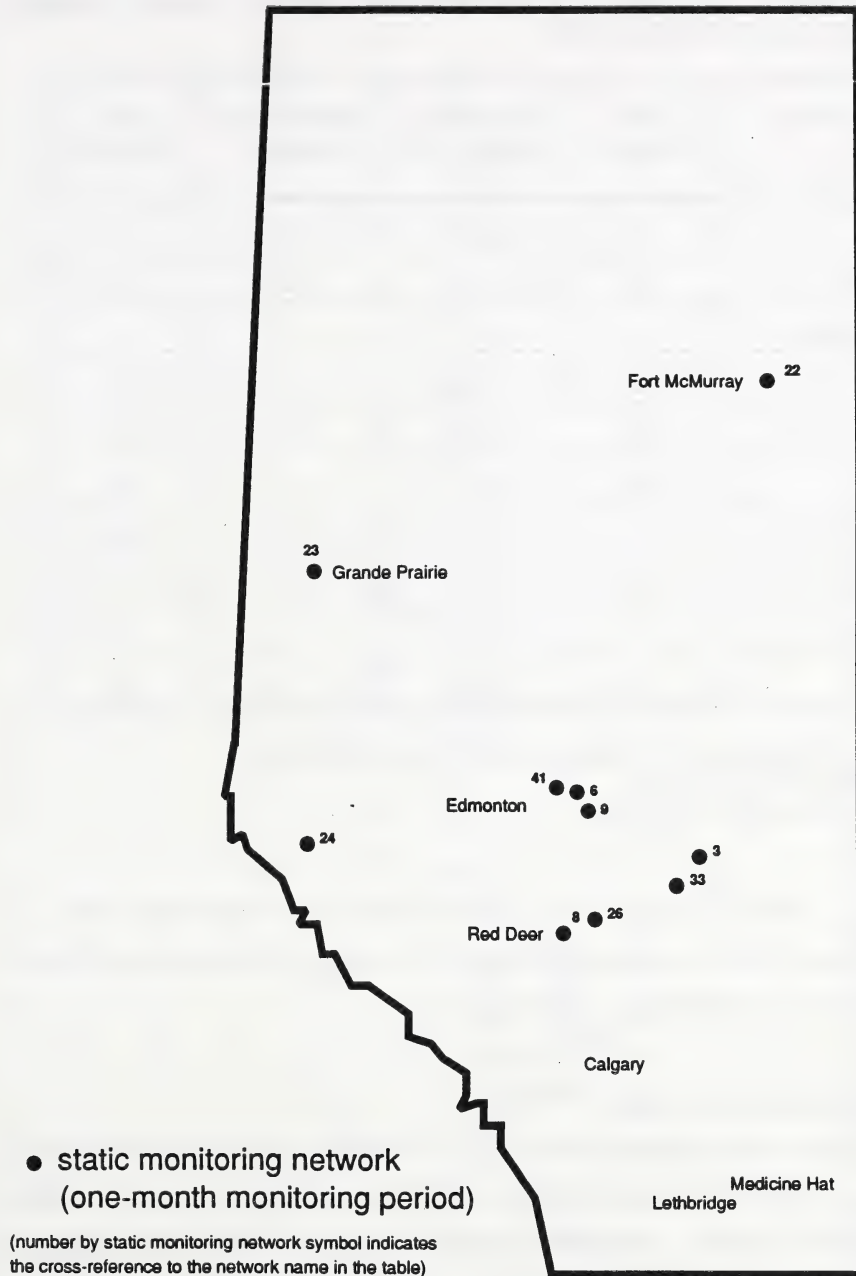


Figure 6-5 Location of hydrogen sulphide monitoring networks.

Table 6.5 Averages and exceedances from networks which monitor hydrogen sulphide on a one-month exposure basis.

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent) ^a	Map Location
Camrose	1	0.012	0	3
Fort McMurray	6	0.018	0	22
Fort Saskatchewan	1	0.017	0	6
Grande Prairie	1	0.006	0	23
Hinton	3	0.006	0	24
Joffre	2	**	**	26
New Norway	1	**	**	33
Red Deer (city)	2	**	**	8
Sherwood Park	3	0.014	0	9
St. Albert	2	0.008	0	41

^a Refers to exceedances of the guideline (0.10 mg/day/100 sq cm).

* ≥50 to <75% of data available.

** Less than 50% of data available.

recorded, respectively. No exceedances of the guideline for H₂S were observed in 1992. A maximum observed monthly H₂S loading of 0.068 and 0.069 mg/day/100 sq cm were recorded at Fort McMurray and Fort Saskatchewan, respectively.

6.4.4.2 Three-Month Exposure Period

A total of 135 static monitoring stations, in 35 networks, measure H₂S on a three-month basis in Alberta. Figure 6-6 shows the location of H₂S networks administered by Alberta Environmental Protection in 1992. Average H₂S loadings for each network and the frequency of exceedances are shown in Table 6.6. Exceedances of the guideline were not recorded at networks which monitor H₂S on a three-month basis. The highest annual average H₂S loadings were observed at the Redwater network where an average value of 0.013 mg/day/100 sq cm was recorded. The overall maximum H₂S loading was 0.032 mg/day/100 sq cm which was measured at the Redwater network. This value is 32% of the guideline for H₂S.



Figure 6-6 Location of hydrogen sulphide monitoring networks.

Table 6.6 Averages and exceedances from networks which monitor hydrogen sulphide on a three-month exposure basis.

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent) ^a	Map Location
Balzac	4	0.006	0	10
Bigstone	2	na	na	12
Blue Ridge	4	na	na	13
Buck Lake	4	na	na	11
Caroline	1	na	na	14
Carstairs	4	0.003	0	16
Cochrane	4	0.005	0	15
Coleman	4	0.008	0	4
Crossfield	5	0.004	0	17
Diamond Valley	4	0.003	0	18
Didsbury	5	na	na	19
Edburg	1	na	na	20
Edson	4	0.001	0	21
Innisfail	2	na	na	25
Jumping Pound	4	0.005	0	27
Kaybob	4	na	na	28
Kaybob (south)	4	na	na	29
Lone Pine Creek	5	0.005	0	30
Mayerthorpe	2	na	na	31
Mazeppa	4	0.003	0	32
Nevis	7	na	na	34
Okotoks	4	0.007	0	35
Olds	4	na	na	36
Pincher Creek	6	0.004	0	37
Quirk Creek	6	0.003	0	38
Ram River	5	na	na	39
Red Deer	4	na	na	8
Redwater	4	0.013	0	50
Rimbey	4	na	na	40
Simonette	2	na	na	42
Sundre	2	na	na	43
Valleyview	2	na	na	44
Waterton	8	0.004	0	45
Wimborne	2	na	na	46
Windfall	4	na	na	47

a Refers to exceedances of the guideline (0.10 mg/day/100 sq cm).

* ≥50 to <75% of data available.

** Less than 50% of data available.

na No data available.

6.5 FLUORIDES

6.5.1 Characteristics

Fluorides are discharged into the atmosphere by industrial operations which involve the combustion of coal, and the processing of phosphate bearing rock. These industrial processes include: the grinding, drying and calcining of phosphate rock for fertilizer; iron and steel production; kiln firing of ceramic materials for bricks; melting of materials for glassmaking and fluoride-based cleaning; and etching and electroplating agents used in manufacturing.

6.5.2 Method of Monitoring

Total fluoride loading is monitored as a monthly accumulated value. Fluorides are collected on a sample plate lined with calcium oxide saturated filter paper. Hydrogen fluoride from the atmosphere reacts with the calcium oxide to form calcium fluoride, water and carbon dioxide. The amount of calcium fluoride in the sample is proportional to the fluoride loading in the sample.

6.5.3 Regulations and Guidelines

In Alberta, industrial sources of fluorides are required to conduct static monitoring. The guideline for fluoride loading is:

- ▲ 40.0 ug water soluble fluorides/100 sq cm /30 days (micrograms of water soluble fluorides per 100 square centimetres per 30 days).

6.5.4 Results

Fluorides were monitored by Alberta Environmental Protection at Fort Saskatchewan and Redwater in 1992. These stations are located near industries, such as brick, tile and fertilizer manufacturing plants, that are industrial sources of fluorides. Figure 6-7 shows the location of these monitoring networks. Table 6.7 indicates the average fluoride loading for each network and the frequency of exceedances for each network.

Average fluoride loadings were 1.0 ug/100 sq cm/30 days at Fort Saskatchewan and 2.8 ug/100 sq cm/30 days at the Redwater monitoring network. Exceedances of the guideline for fluoride did not occur in 1992. The maximum fluoride loading was 11.3 ug/100 sq cm/30 days which was recorded at the Redwater network.

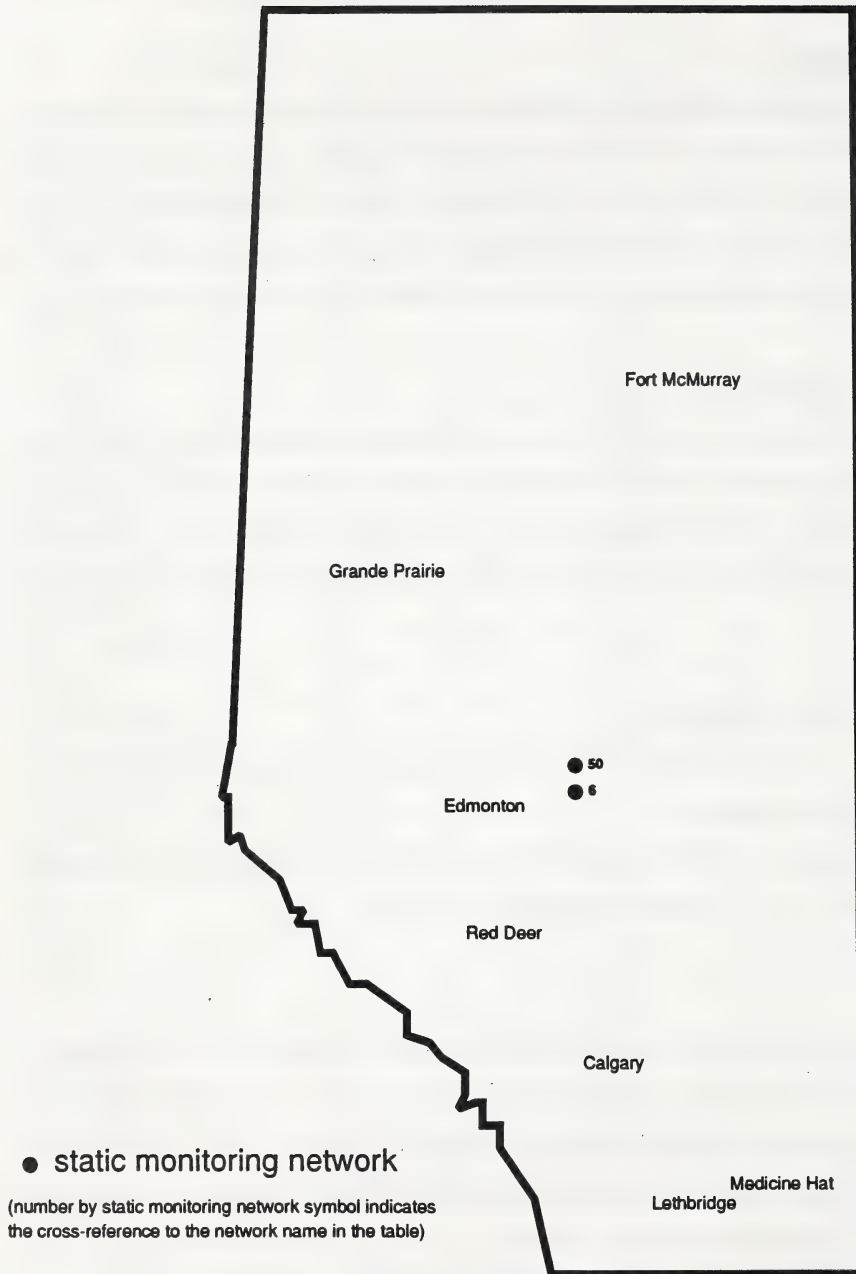


Figure 6-7 Location of fluoride monitoring networks.

Table 6.7 Averages and exceedances from networks which monitor fluorides.

Network Location	# of Stations	Average (ug/100 sq cm/30 days)	Exceedances (percent)^a	Map Location
Fort Saskatchewan	1	1.0	0	6
Redwater	4	2.8	0	50

a Refers to exceedances of the guideline (40.0 ug/100 sq cm/30 days).

***** ≥50 to <75% of data available.

****** Less than 50% of data available.

7. ACID PRECIPITATION MONITORING RESULTS

7.1 CHARACTERISTICS

There is an increasing public awareness of the occurrence and effects of acidic substances in the atmosphere. Acidic substances contained in the atmosphere will eventually be deposited on the earth's surface in the form of precipitation (wet deposition) or particulates and gases (dry deposition).

The effects of acid deposition vary depending on the amount of acidic pollutants being deposited and the buffering capacity (ability of soil or water to neutralize the acidity of the precipitation) of the receptor. In the eastern North America and Europe, changes in aquatic life, changes to forest and crop growth, and damage to buildings and equipment have been attributed to acid deposition.

Since 1978, precipitation chemistry measurements have been conducted by Alberta Environmental Protection. The objectives of the acid precipitation program are to: (1) monitor the quality of precipitation; (2) detect any significant trends in precipitation quality; and (3) determine long-range transport of pollutants into the province.

7.2 METHOD OF MONITORING

Precipitation is collected by a sampler that opens automatically when precipitation (rain or snow) occurs and closes when the precipitation ceases. Each month, the sample is retrieved from the field and sent to the laboratory for analysis. Data obtained as a result of analysis include pH, strong acidity, total acidity, specific conductance, major cations (calcium, ammonium, sodium, magnesium and potassium) and major anions (sulphate, nitrate, chloride and phosphate).

7.3 REGULATIONS AND GUIDELINES

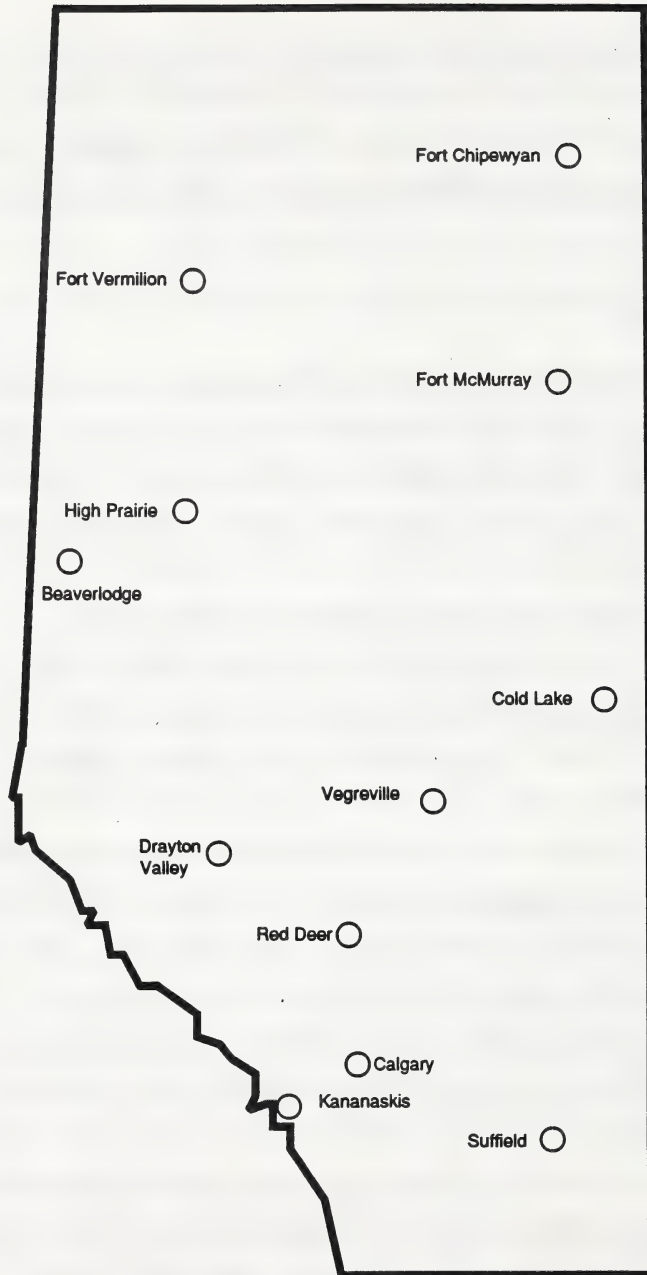
Wet sulphate deposition is often used as an indicator of wet deposition. In eastern Canada, the relationship between hydrogen and sulphate ions is strong enough to establish a basis for wet deposition standards. An objective of 20 kg/ha/yr (kilograms per hectare per year) has been adopted for wet sulphate deposition in eastern Canada. In western Canada, it has been shown that the hydrogen-sulphate ion relationship is not strong enough to use as a basis for wet

deposition standards (Lau 1982; Sandhu and Blower 1986; Bertram et al. 1987; Legge 1988). Other ions such as calcium and magnesium are associated with sulphate ions to form non-acidifying substances such as calcium sulphate and magnesium sulphate. Alberta Environmental Protection is currently exploring alternate approaches for determining target loading objectives for acidic deposition.

7.4 RESULTS

The locations of Alberta Environmental Protection precipitation monitoring stations are indicated in Figure 7-1. Precipitation data was collected on a monthly basis from January to August and on a weekly basis from September to December at most stations in 1992. Samples were collected on a daily, weekly and monthly basis at Vegreville as part of the Alberta Environmental Protection Acid Deposition Program. Only monthly data from Vegreville will be presented here (daily and weekly data are presented by Peake (1993)).

Samples which remain in the field for a longer period of time (i.e. one month as compared to one week) will generally have higher pH values and higher concentrations of some other ions (Lau 1990). This is due to chemical reactions which take place in the field during the sampling period. Based on this observation, it is important to emphasize that monthly and weekly pH, ion deposition rates and effective acidity deposition rates are not directly comparable. However, for the purpose of obtaining annual pH values, volume weighted average hydrogen ion concentrations from weekly and monthly samples were calculated. Annual anion, cation and effective acidity deposition rates were also calculated simply as the sum of the monthly and weekly values. Precipitation depths used in calculating wet deposition and effective acidity values were estimated using the volume of precipitation collected in each sample. Wet deposition rates are presented in units of kilograms per hectare which essentially is the total mass of a specific contaminant deposited onto one hectare during the monitoring period by precipitation. Effective acidity is presented as kilograms of hydrogen ion equivalents per hectare. Greater than or equal to 75% of data must be available to compute representative annual wet deposition rates. Wet deposition estimates are not available for Fort Chipewyan due to a lack of data. Table 7.1 shows volume-weighted average pH values, anion and cation wet deposition rates, and the calculated effective acidity deposition rates for monthly and weekly precipitation samples.



○ acid precipitation monitoring network

Figure 7-1 Location of acid precipitation monitoring stations.

Table 7.1 pH, wet deposition rates, and effective acidity of precipitation at monitoring stations which collected samples on a monthly (January to August) and weekly (September to December) basis.

Station	Sampling Period	pH ^a	Anions (kg/ha)				Cations (kg/ha)					Effective Acidity (kg/ha of eq. H ⁺)
			SO ₄ ⁻	NO ₃ ⁻	Cl ⁻	PO ₄ ⁻	Ca ⁺⁺	NH ₄ ⁺	Na ⁺	Mg ⁺⁺	K ⁺	
Eaverlodge	monthly	4.9	1.5	0.9	0.2	0.0	0.2	0.2	0.1	0.1	0.1	0.03
	weekly	5.1	0.4	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.00
	annual	5.0	1.9	1.1	0.2	0.0	0.3	0.2	0.1	0.1	0.1	0.03
Calgary	monthly	5.9	5.2	2.6	0.5	0.4	1.4	3.5	0.4	0.3	0.3	0.20
	weekly	5.3	0.8	0.5	0.1	0.0	0.2	0.2	0.1	0.0	0.0	0.01
	annual	5.7	6.0	3.1	0.6	0.4	1.6	3.7	0.5	0.3	0.3	0.21
Cold Lake	monthly	5.2	1.6	1.3	0.1	0.0	0.3	0.5	0.1	0.1	0.1	0.03
	weekly	5.2	0.4	0.6	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.01
	annual	5.2	2.0	1.9	0.2	0.0	0.4	0.6	0.1	0.1	0.1	0.04
Cratton Valley	monthly	5.5	3.0	1.5	0.1	0.0	0.6	1.3	0.1	0.1	0.2	0.07
	weekly	5.4	0.5	0.3	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.01
	annual	5.4	3.5	1.8	0.2	0.0	0.7	1.4	0.2	0.1	0.2	0.08
Fort Chipewyan	monthly	5.4 [*]	*	*	*	*	*	*	*	*	*	*
	weekly	4.8 [*]	*	*	*	*	*	*	*	*	*	*
	annual	5.2 [*]	*	*	*	*	*	*	*	*	*	*
Fort McMurray	monthly	4.7	3.6	1.4	0.1	0.0	0.4	0.4	0.1	0.1	0.1	0.05
	weekly	4.7	0.9	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.02
	annual	4.7	4.5	1.7	0.2	0.0	0.4	0.5	0.1	0.1	0.1	0.07
Fort Vermilion	monthly	5.2	1.3	0.7	0.3	0.0	0.6	0.1	0.1	0.1	0.3	0.01
	weekly	5.3	0.3	0.2	0.3	0.0	0.1	0.0	0.2	0.0	0.1	0.00
	annual	5.2	1.6	0.9	0.6	0.0	0.7	0.1	0.3	0.1	0.4	0.01
High Prairie	monthly	5.1	1.5	0.9	0.1	0.1	0.2	0.3	0.0	0.1	0.2	0.02
	weekly	5.1	0.5	0.3	0.1	0.0	0.5	0.0	0.1	0.0	0.1	0.01
	annual	5.1	2.0	1.2	0.2	0.1	0.7	0.3	0.1	0.1	0.3	0.03
Hananaskis	monthly	5.1	4.6	2.7	0.2	0.0	1.2	0.7	0.1	0.2	0.1	0.06
	weekly	4.7	0.9	0.8	0.1	0.0	0.3	0.1	0.1	0.1	0.0	0.01
	annual	5.0	5.5	3.5	0.3	0.0	1.5	0.8	0.2	0.3	0.1	0.07
Hed Deer	monthly	5.2	3.2	2.2	0.1	0.0	0.6	1.1	0.1	0.1	0.1	0.06
	weekly	5.2	1.1	0.8	0.0	0.0	0.2	0.4	0.0	0.1	0.0	0.02
	annual	5.2	4.3	3.0	0.1	0.0	0.8	1.5	0.1	0.2	0.1	0.08
Vegreville	monthly ^b	5.3	3.1	2.3	0.1	0.0	0.5	1.3	0.1	0.1	0.1	0.07
Wainfield	monthly	5.5	2.5	2.3	0.2	0.0	0.6	0.8	0.2	0.2	0.1	0.04
	weekly	5.5	0.5	0.5	0.1	0.0	0.2	0.2	0.0	0.0	0.1	0.00
	annual	5.5	3.0	2.8	0.3	0.0	0.8	1.0	0.2	0.2	0.2	0.04

≥50 to <75% of data available.

Less than 50% of data available.

Based on the volume weighted average of monthly hydrogen ion concentrations.

Monthly sampling conducted at Vegreville station from January to December, 1992.

7.4.1 pH

Uncontaminated precipitation is slightly acidic (pH of 5.6) due to the presence of carbon dioxide. When pollutants such as sulphur dioxide and nitric oxides are emitted into the atmosphere, sulphates and nitrates are formed through oxidation. Sulphates and nitrates combine with water vapour to form sulphuric and nitric acids. The presence of these acids causes precipitation to become more acidic (lower pH).

The most acidic precipitation in 1992 occurred at Fort McMurray where a volume weighted average pH value of 4.7 was recorded from monthly and weekly samples. Beaverlodge, Kananaskis, High Prairie, Fort Chipewyan, Fort Vermilion, Red Deer and Cold Lake all recorded volume weighted annual pH values from 5.0 to 5.2. Annual pH values close to that of uncontaminated precipitation were measured at Calgary (5.7) and Suffield (5.5). The lowest monthly and weekly pH values were recorded at Fort McMurray (4.51) and Calgary (4.33), respectively. Maximum monthly and weekly pH values of 7.16 and 8.01, respectively, were observed at High Prairie.

7.4.2 Anion Deposition (sulphate, nitrate, chloride and phosphate)

Anions are negatively charged groups of atoms or molecules formed when chemicals dissociate in water. Sulphuric acid and nitric acid produce sulphate and nitrate ions, respectively, and these are often used as a measure of acidity. Parent chemicals may be emitted into the atmosphere by gas plants, oil sands plants, coal-fired power plants, oil refineries, pulp and paper mills, fertilizer plants and agricultural activities.

Annual anion wet deposition rates were calculated as the sum of monthly and weekly deposition rates. The highest wet sulphate deposition rates occurred at Calgary and Kananaskis where values of 6.0 and 5.5 kg/ha/yr were recorded, respectively. Sulphate deposition rates greater than 4.0 kg/ha/yr were recorded at Fort McMurray (4.5 kg/ha/yr) and Red Deer (4.3 kg/ha/yr). These values are well below the eastern Canada objective of 20 kg/ha/yr for wet sulphate. The lowest wet sulphate deposition values was recorded at Fort Vermilion (1.6 kg/ha/yr).

A maximum nitrate wet deposition rate of 3.5 kg/ha/yr was recorded at the Kananaskis monitoring station. Values greater than or equal to 3.0 kg/ha/yr were also recorded at Calgary

and Red Deer. Minimum rates were observed at High Prairie (1.2 kg/ha/yr), Beaverlodge (1.1 kg/ha/yr) and Fort Vermilion (0.9 kg/ha/yr).

Maximum wet chloride deposition rates of 0.6 kg/ha/yr were recorded at Calgary and Fort Vermilion. The remaining precipitation monitoring stations recorded a wet deposition rate for chloride of less than or equal to 0.3 kg/ha/yr.

Wet phosphate deposition rates were below the limit of detection the majority of the time at all locations. Detectable phosphate deposition values were observed at Calgary (0.4 kg/ha/yr) and High Prairie (0.1 kg/ha/yr).

7.4.3 Cation Deposition (calcium, ammonium, sodium, magnesium and potassium)

Cations are positively charge groups of atoms or molecules formed when chemical compounds dissociate in water. All solutions are electronically neutral and, therefore, each anion will be balanced by a cation. Many parent chemicals will emanate from industrial sources such as iron, steel, wood, coal and cement manufacturing. A large percentage of cations will also be contained in wind-blown soil and dust. The annual wet deposition rates reported here are the sum of deposition rates obtained from monthly and weekly samples.

Wet calcium deposition was a maximum at Calgary and Kananaskis where values of 1.6 and 1.5 kg/ha/yr were recorded, respectively. Minimum wet calcium deposition rates were recorded at Beaverlodge (0.3 kg/ha/yr), Cold Lake (0.4 kg/ha/yr) and Fort McMurray (0.4 kg/ha/yr).

A maximum annual ammonium wet deposition rate of 3.7 kg/ha/yr was recorded at the Calgary precipitation station. Minimum values of were observed at Fort Vermilion (0.1 kg/ha/yr), Beaverlodge (0.2 kg/ha/yr) and High Prairie (0.3 kg/ha/yr).

Wet sodium, magnesium and potassium deposition rates were less than or equal to 0.5 kg/ha/yr at all precipitation monitoring stations. Maximum magnesium wet deposition rates of 0.3 kg/ha/yr were recorded at the Calgary and Kananaskis stations. Wet potassium deposition rates were the greatest at Fort Vermilion (0.4 kg/ha/yr), High Prairie (0.3 kg/ha/yr) and Calgary (0.3 kg/ha/yr). Wet sodium deposition rates varied from 0.1 kg/ha/yr to 0.5 kg/ha/yr at Calgary.

7.4.4 Effective Acidity

Effective acidity (EA) is an approach which has been developed to estimate the degree of acidification which soil would experience as a result of atmospheric inputs. This approach takes into account: (1) direct deposition of acids onto the soil; and (2) the chemical, biological and physical processes which take place within the soil as a result of acid deposition. Effective acidity is described by the equation:

$$EA = [H^+] + 1.15x[NH_4^+] - 0.7x[NO_3^-]$$

where $[H^+]$, $[NH_4^+]$ and $[NO_3^-]$ are concentrations of hydrogen ions, ammonia ions and nitrate ions, respectively, expressed as molar equivalents (Coote et al, 1981). The hydrogen ion concentration is a measure of acidic compounds deposited directly to the soil. The terms $1.15x[NH_4^+] - 0.7x[NO_3^-]$ indicate the estimated effect of wet ammonia and nitrate deposition which will indirectly generate acidity in the soil. When ammonia is nitrified (converted to nitrate), volatilized (lost to the atmosphere), fixed or taken up by plants, then the net effect is an increase in hydrogen ion concentration and, therefore, an increase in the acidity of the soil. The processes of denitrification, nitrate leaching and plant uptake of nitrate lead to a net reduction of the hydrogen ion concentration and, therefore, a net decrease in the acidity of the soil. The effective acidity equation takes into account the relationship between these processes within the soil. It is important to note that the calculations presented here reflect the effective acidity calculated from wet deposition. It is expected that the contribution of dry deposition is at least 40% of total deposition. In Table 7.1, annual effective acidity deposition rates are the sum of monthly and weekly deposition rates.

Effective acidity deposition rates range from 0.01 kg/ha/yr Fort Vermilion to 0.21 kg/ha/yr at Calgary. The remaining monitoring stations indicate effective acidity deposition rates from 0.03 to 0.08 kg/ha/yr. These values are comparable to long-term (1978 to 1990) average effective acidity deposition values presented by Peake and Wong (1992). Long term average effective acidity deposition rates range from 0.04 kg/ha/yr at High Prairie, High Level and Lethbridge to 0.19 kg/ha/yr at Suffield. Relatively high long-term average values are also evident at Edmonton (0.13 kg/ha/yr), Red Deer (0.13 kg/ha/yr) and Calgary (0.11 kg/ha/yr). The proposed range of limits to acidic deposition for sensitive soils using the effective acidity concept is 0.1 to 0.3 kg/ha/yr of H^+ for soils (Alberta Environment, 1990). Effective acidity deposition rates within this range were observed only at Calgary in 1992.

8. REFERENCES

- Alberta Energy. 1990. Energy-related carbon dioxide emissions in Alberta: 1988 - 2005. Energy Efficiency Branch, Alberta Department of Energy. May 1990.
- Alberta Energy. 1990. Sulphur emissions forecast for Alberta. Alberta Energy/Energy Resources Conservation Board. August 1990.
- Alberta Environment. 1990. A review of approaches for setting acidic deposition limits in Alberta.
- Alberta Environment. 1990. Energy-related nitrogen oxide emissions in Alberta: 1988-2005. Draft. Energy Resources Conservation Board/Alberta Environment. August 1990.
- Alberta Environment. 1985. Methods manual for chemical analysis of atmospheric pollutants. Air Analysis and Research Group, Alberta Environmental Centre. AECV85-M1
- Angle, R.P and H.S. Sandhu. 1989. Urban and rural ozone concentrations in Alberta, Canada. *Atmospheric Environment* 23:215-221.
- Bertram, H.L., D.R. Chalupa, and Y.K. Lau. 1987. The role of the ammonium ion in acid deposition. PNWIS/APCA 1987 Annual Meeting; Seattle, Washington, November 9 and 10.
- Coote, D.R., D. Siminovitch, S.S. Sing and C. Wang. 1981. The significance of acid rain to agriculture in Eastern Canada. Agriculture Canada, Ottawa, LRRI Contribution 119, CBRI Contribution 1236. pp 26.
- Environment Canada. 1984. Identification of sources of inhalable particulates in Canadian urban areas. Final Report. Environmental Protection Services.
- Environment Canada. 1980. Guideline for a short-term air quality index. A report by the Federal-Provincial committee on Air Pollution.
- Lau, Y.K. 1982. Precipitation Chemistry. Air Quality Control Branch, Pollution Control Division, Alberta Environment. Edmonton, Alberta. 75 pp.
- Lau, Y.K. 1990. A comparison of daily and monthly precipitation chemistry data at Esther and High Prairie. Scientific Services. A.E.S. Western Region. Report 90-3.
- Legge, A.H. 1988. The present and potential effects of acidic and acidifying air pollutants on Alberta's environment. Critical Point I - Final report. Prep. for the Acid Deposition Research Program by the Kananaskis Centre for Environmental Research, University of Calgary; Calgary, Alberta. ADRP-B-16-88. 79 pp.

- Myrick, R.H. 1992. An evaluation of air quality at two sites in the Lower Townsite of Fort McMurray: October 1, 1991 to June 30, 1992. Technical Report No. 92-3. Environmental Assessment Division, Alberta Environment.
- Peake, E. 1993. Acid deposition program progress report: Technology evaluation and deposition velocity projects. Environmental Research and Engineering Department, Alberta Research Council. Prepared for the Alberta Environment Acid Deposition Program.
- Peake, E. and R. Wong. 1992. An evaluation of precipitation measurements in Alberta (1978-1990). Final Report to the Environmental Quality Monitoring Branch of the Environmental Assessment Division of Alberta Environment.
- Sandhu, H.S. and L. Blower. 1986. Acid-forming emissions in Alberta, Canada. Environ. Mgmt. 10:689-695.
- U.S. Environmental Protection Agency. 1974. Guidelines for the evaluation of air quality trends. Guideline Series. OAQPS No. 1.2-014. Office of Air Quality Planning and Standards, Monitoring and Data Analysis Division, Research Triangle Park, North Carolina, 227711.
- World Health Organization. 1980. Analysing and interpreting air monitoring data. GEMS: Global Environmental Monitoring System. WHO offset publication No. 51.

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